L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

ADVANCED MATRICULATION LEVEL
2025 FIRST SESSION

SUBJECT:	**Computing**
PAPER NUMBER:	I
DATE:	20th May 2025
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. A digital system processes a four-bit two's complement binary number B as its input. The output Z is defined as follows: Z = 1 when B ≤ 2 and Z = 0 otherwise.

   a. Draw the truth table for Z covering **all** possible 4-bit 2's complement values for B. (2)
   b. Use a Karnaugh map to derive a simplified Boolean expression for Z, considering **all** four bits of B in a 4-bit 2's complement representation. (3)

(Total: 5 marks)

2. Boolean expressions represent the logic of digital circuits, using variables that can be true or false to simplify circuit design.

   a. Using Boolean algebra, show that:

$$A(BA + DD) + \overline{CA} = B + D + \overline{C} + \overline{A} \quad (3)$$

   b. Design the logic circuit for the Boolean expression derived in part (a) using AND, OR and NOT gates. (2)

(Total: 5 marks)

3. Examine the following code snippet.

```
MOV BX, 3          ; Load the value 3 into BX
MOV DX, 4          ; Load the value 4 into DX
loop: ADD BX, 5    ; Increment the value of BX by 5
DEC DX             ; Subtract one from DX
JNE loop           ; Jump to label loop if DX is not 0
```

   Determine the contents of the register BX after the above assembly code snippet is executed. **All** working must be shown.

(Total: 5 marks)

Please turn the page.

4. Consider the following assembly code instructions.

```
MOV AX, 11010110 ; Load into AX the binary number 11010110
SHR AX, 1        ; Logical Shift Right by 1 bit & put the result in AX
SHL AX, 2        ; Logical Shift Left by 2 bits & put the result in AX
```

   a. What is the binary value inside AX after the given instructions are executed? (2)
   b. What is the effect of a logical right shift on the binary value? (1)
   c. If another logical right shift (`SHR AX, 1`) instruction was executed on the final value of `AX`, what would be the resulting binary value? (2)

(Total: 5 marks)

5. Networks and communication technologies are fundamental to modern computing and play a critical role in the efficient exchange of information. Understanding the components, topologies, and security concerns of these systems is essential for ensuring smooth and secure operations.

   a. Explain the main function of a router in a network. (1)
   b. Name and describe any **TWO** network topologies used in local area networks (LANs). (2)
   c. What is the purpose of the Domain Name System (DNS) in networking? (1)
   d. Identify **ONE** potential security threat to a network and suggest how to mitigate it. (1)

(Total: 5 marks)

6. Protocols play a crucial role in enabling communication between devices on a network, ensuring data is transmitted securely and reliably. The OSI model further standardises these processes by dividing them into functional layers.

   a. Define what a network protocol is and explain why protocols are essential for communication between different networks. (2)
   b. Name the OSI layer responsible for the following functions:
      i. data encryption and decryption. (1)
      ii. routing packets between devices on different networks. (1)
      iii. ensuring reliable data transmission by detecting and correcting errors. (1)

(Total: 5 marks)

7. The university is planning to implement a new system to manage student enrolment, grades and course schedules. The project has gone through the feasibility study phase and the next step is to gather system requirements.

   a. Describe at least **TWO** methods of requirements elicitation that can be used to gather the necessary information from university stakeholders. (2)
   b. For **each** method mentioned in part (a), provide **ONE** advantage and **ONE** disadvantage. (2)
   c. Explain the purpose of a Data Flow Diagram (DFD) in system analysis. (1)

(Total: 5 marks)

8. The public hospital has decided to develop a new system to manage patient records and appointments. During the system design phase, the project team must specify the design aspects of the system.

   a. Describe what is meant by top-down and bottom-up approaches in system design. (2)
   b. Which approach would be more beneficial in this scenario and why? (3)

(Total: 5 marks)

9. A sports equipment store wants to design a database system to manage its inventory and customer orders. The system should store information about the products, customers, and orders. The store wants to track the following attributes.

ProductName	CustomerEmail
ProductID	OrderNumber
ProductCategory	OrderDate
CustomerID	ShippingAddress
CustomerName	

   Design the database tables to store the above information. Ensure that you organise the data into appropriate tables, and include primary and foreign keys where necessary.

(Total: 5 marks)

10. Entity-Relationship models are essential in database design to graphically represent entities, their attributes and the relationships between them. They help structure data logically while ensuring clarity and accuracy in relational database design.

    a. Using the "Crow's Foot" notation, illustrate the relationship between the following entities in a library system and describe the cardinality between them.
       i. Books (attributes: BookID, Title, Author)
       ii. Members (attributes: MemberID, Name, MembershipDate)
       iii. Loans (attributes: LoanID, LoanDate, DueDate) (2)

    b. A university database stores Course, Professor and Department details, but duplicate information about professors appears across different courses.

       Explain how normalisation up to Third Normal Form (3NF) resolves the above issue. Provide a simple example to support your explanation. (3)

(Total: 5 marks)

11. New computer science students would like to understand the inner workings of a CPU, focusing on the roles of the Control Unit (CU), Arithmetic Logic Unit (ALU), and key registers.

    a. Define the purpose of the following registers:
       i. Memory Address Register (MAR); (1)
       ii. Current Instruction Register (CIR); (1)
       iii. Program Counter (PC). (1)
    b. Explain briefly the function of the CU in a computer system. (1)
    c. Describe the role of the ALU. (1)

(Total: 5 marks)

Please turn the page.

12. A team of engineers is developing embedded systems for the automotive industry. They are debating about which type of ROM would be more suitable for their project.

    a. Define the following types of ROM and describe **ONE** key characteristic of **each**.
       i. PROM;
       ii. EPROM. (3)

    b. Provide **ONE** practical application where EPROM would be better than PROM in the automative industry and justify your answer. (2)

(Total: 5 marks)

13. A text file named '`examQuestions.txt`' needs to be stored on disk.

    a. Mention and describe the **THREE** main file allocation methods that can be used for the storage of such files. (3)
    b. Choose **ONE** allocation method from part (a) and draw a diagram showing how the file '`examQuestions.txt`' is stored across 6 blocks, given 16 available blocks. Include a representation of the directory entry and state any assumptions about the attributes stored in the directory. (2)

(Total: 5 marks)

14. A systems administrator in a multitasking environment is monitoring processes and ensuring they transition smoothly between states.

    a. Draw a diagram to show how a process transitions between the main states during its execution. (2)
    b. Describe **each** of the states listed in part (a). (3)

(Total: 5 marks)

15. Languages play a crucial role in communication and problem-solving.

    a. Differentiate between natural languages and formal languages. (2)
    b. Give **ONE** example of **each** of the two languages mentioned in part (a). (1)
    c. Explain the concepts of syntax and semantics in a language, and discuss why both are important in programming. (2)

(Total: 5 marks)

16. A technology company is developing a suite of software applications to improve its operations. These applications are written in different programming languages by various programmers and must be converted into machine code for execution.

    a. Identify and define **THREE** types of language translators that can be used to convert code into machine language. (3)
    b. Provide an example of a programming language for **TWO** of the language translators identified in part (a). (1)
    c. Discuss the role of Just-In-Time (JIT) compilation in ensuring efficient execution of these applications, considering the variety of programming languages used. (1)

(Total: 5 marks)

17. A programming language defines the following grammar for arithmetic expressions:

$$E \rightarrow E + T$$

$$E \rightarrow +T$$

$$T \rightarrow T * F$$

$$T \rightarrow F$$

$$F \rightarrow (E)$$

$$F \rightarrow id$$

a. Using the grammar rules above, construct a top-down parse tree for the statement

$$id + id * id$$ (3)

b. What is a bottom-up parse tree, and how does it work? (2)

(Total: 5 marks)

18. A software team is optimising data storage and retrieval and must choose between static and dynamic data structures.

a. Explain the difference between static and dynamic implementation of data structures. (1)
b. State **ONE** advantage and **ONE** disadvantage of **each**. (2)
c. Briefly describe how an array can be used to implement a queue data structure. Provide a simple example to illustrate this. (2)

(Total: 5 marks)

19. A company needs an efficient way to store and retrieve customer records. The software team decides to use a hash table as part of the solution.

a. Explain the hash table data structure. (1)
b. Explain how collisions can occur in a hash table. (1)
c. Using the modulus method, create the hash address for the insertion of the following values into a hash table. Are there any collisions? How can they be resolved?

12, 26, 31, 19

(3)

(Total: 5 marks)

20. Queues play a critical role in many programming applications.

a. Define the queue data structure and explain its behaviour. (1)
b. Write a pseudo-code algorithm to demonstrate the creation of a queue, the addition and removal of an item from it, and querying the number of items in the queue. (4)

(Total: 5 marks)

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MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

ADVANCED MATRICULATION LEVEL
2025 FIRST SESSION

SUBJECT:	**Computing**
PAPER NUMBER:	II
DATE:	20th May 2025
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 smart home system is designed to manage lights, alarms, and energy efficiency. The system uses binary signals (1 for ON/active and 0 for OFF/inactive) and processes data using binary arithmetic, logic gates and hexadecimal representation. It also includes features like monitoring sensor data and enabling power-saving modes based on specific conditions. Analyse and assist in optimising this system by answering the following questions.

   a. The system monitors temperature sensors that send binary signals (1's and 0's). Convert the following sensor readings to decimal.
      i. 101101 (temperature in binary) (1)
      ii. 1101000 (temperature in binary) (1)
   b. Two energy monitoring devices, A and B, send binary signals representing power usage as 01101101 and 10011110, respectively. Perform binary addition to calculate the total power usage. Indicate if there is an overflow in the 8-bit system. (2)
   c. The system logs device errors using hexadecimal codes. Convert the following error codes to binary and decimal.
      i. 3A (2)
      ii. B7 (2)
   d. The system uses hexadecimal representation for error codes displayed to the user. Explain **TWO** advantages of using hexadecimal over binary in this context. (2)
   e. The smart lighting system uses the following rule: Lights turn ON (L=1) if motion is detected (M=1) and the manual override switch is OFF (O=0).
      Draw the truth table for this condition. (3)
   f. The alarm system activates (A=1) under the following conditions: The main door sensor detects an intrusion (D=1), or both the motion sensor (M=1) and the window sensor (W=1) detect movement.
      i. Write the Boolean expression for the alarm activation. (2)
      ii. Can the expression can be simplified further? Why? (1)
      iii. Produce the truth table for the simplified circuit. (2)
      iv. Draw a logic circuit based on this Boolean expression. (2)

(Total: 20 marks)

Please turn the page.

2. A processor based on the 8086 architecture is used to control a robot arm. The robot's instructions are implemented using an assembly language program. The code fragment provided below is used to read sensor data, process it, and control the arm's movement.

```
MOV AX, 0810H   ; Load the value from memory address 0810H into AX
MOV BX, #03H    ; Load the immediate value 3 into BX
ADD AX, BX      ; Add the contents of BX to AX
MOV [BX], AX    ; Store AX at the memory address in BX
INC BX          ; Increment the value of BX by 1
MOV CX, [BX+DX] ; Load the value from the memory address BX+DX into CX
```

   a. Define the terms opcode and operand in the context of assembly language instructions. (2)
   b. Identify **TWO** examples of mnemonics in the code fragment and explain the purpose of **each** mnemonic. (2)
   c. Describe the purpose of the AX register in this program. (1)
   d. What is the significance of using BX and DX in the given code? (2)
   e. Explain the difference between immediate addressing and indirect addressing, providing examples from the code. (4)
   f. Identify the addressing mode used in **each** of the following instructions from the code fragment and explain how the data is accessed.
      i. MOV AX, 0810H
      ii. MOV BX, #03H
      iii. MOV [BX], AX
      iv. MOV CX, [BX+DX] (4)
   g. Explain the role of the assembly process, including assembling, linking, and loading, in creating an executable program from the given code fragment. (2)
   h. Describe the differences between the following types of assemblers:
      i. cross assemblers;
      ii. macro assemblers;
      iii. meta assemblers. (3)

(Total: 20 marks)

3. The university is upgrading its campus-wide network to support high-speed Internet access, seamless communication, and reliable data transfer between departments and student facilities. The network includes both wired and wireless connections, uses various data communication technologies, and ensures error detection for data integrity. The university's IT team is also implementing protocols to manage web access and email communication effectively, prioritising both secure and efficient data transmission across all devices and platforms.

   a. Define simplex and full-duplex communication. (2)
   b. Provide an example of how simplex and full-duplex communication might be used in the university's network. (2)
   c. Define modulation and explain why it is important for data transmission. (2)
   d. Compare amplitude and frequency modulation, emphasizing one key advantage of using one over the other. (2)
   e. Define electro-magnetic interference and explain how it might affect data transmission in the campus network. (3)
   f. Describe how parity checks and checksums work as error detection methods. (2)
   g. Which of these methods is more suitable for detecting multiple errors, and why? (1)

h. Explain the purpose of SMTP and describe how it is used in the university's email system for sending emails. (2)

i. The university has recently implemented IMAP for email retrieval. Explain the function of IMAP and why it might be preferred over POP3 for students accessing their email on multiple devices. (2)

j. Describe the difference between HTTP and HTTPS and explain why the university should use HTTPS for its online student portal. (2)

(Total: 20 marks)

4. Alex is organising a basketball tournament and has created a table called "tournament" to store information about players, teams, and scores. The table has the following fields: Player, ContactDetails, Team, TeamColour and PointsScored. Alex needs to track the performance of each player in different teams.

Player	ContactDetails	Team	TeamColour	PointsScored
John Smith	john@basketball.com	Red Dragons	Red	25
Mary Johnson	mary@basketball.com	Blue Sharks	Blue	30
Mike Davis	mike@basketball.com	Red Dragons	Red	20
Anna Lee	anna@basketball.com	Green Wolves	Green	15
Tom Harris	tom@basketball.com	Blue Sharks	Blue	40
Emma Clark	emma@basketball.com	Green Wolves	Green	35
Luke Allen	luke@basketball.com	Red Dragons	Red	28
Sophie Walker	sophie@basketball.com	Green Wolves	Green	10

a. Write down the output of the following SQL queries.

i.
```
SELECT Player, PointsScored
FROM tournament
WHERE PointsScored > 20
ORDER BY PointsScored DESC;
```
(2)

ii.
```
SELECT Team, AVG(PointsScored) AS AvgPoints
FROM Players
GROUP BY Team
HAVING AVG(PointsScored) > 25;
```
(4)

b. State **TWO** issues with how the data is stored in the above table. (2)

c. Transform the table above to 3rd Normal Form (3NF) showing **all** steps involved using standard notation with explanations. (6)

d. What are the primary responsibilities of a database administrator (DBA)? (1)

e. Describe the **THREE** levels of database schema and explain their roles. (3)

f. What are the key measures that should be implemented to ensure database security? (2)

(Total: 20 marks)

Please turn the page.

5. In modern computing, efficient memory management is critical for maintaining system performance and reliability. Understanding the organisation, characteristics, and integration of memory components is essential for designing efficient computer systems.

   a. Draw a labelled diagram of a typical RAM chip, clearly indicating the following components:
      i. Chip Select lines; (1)
      ii. Data Input Lines; (1)
      iii. Data Output Lines; (1)
      iv. Address Input Lines; (1)
      v. Write Enable and Read Enable lines. (1)
   b. Compare Dynamic RAM (DRAM) and Static RAM (SRAM) in terms of:
      i. structure; (2)
      ii. speed; (2)
      iii. power consumption; (2)
      iv. application. (2)
   c. Define the concept and purpose of a Memory Address Map in a computer system, and explain its role in efficiently managing memory allocation in a multi-tasking environment. (2)
   d. Outline the role of address decoders in connecting memory to the CPU by mentioning at least **TWO** of its key functions. (2)
   e. Draw a schematic diagram showing the function of an address decoder in conjunction with memory. (3)

(Total: 20 marks)

6. A systems engineer is tasked with optimising the I/O operations of a robotics manufacturing system. The system comprises several sensors, actuators, and controllers that communicate with the CPU to ensure precision and efficiency.

   a. The system uses both memory-mapped I/O and isolated I/O to manage different peripherals.
      i. Explain the difference between these **TWO** I/O methods. (2)
      ii. Provide **ONE** scenario where **each** of the I/O methods mentioned in part (a), would be appropriate for the robotics manufacturing system. (2)
   b. Reliable data transfer is critical between the CPU and the sensors.
      i. Describe the concept of handshaking and its purpose in device communication. (2)
      ii. Provide **TWO** examples of how it ensures reliable communication in the system's sensor network. (2)
   c. The system uses a mix of interrupts and polling to handle I/O operations.
      i. Describe the above-mentioned **TWO** approaches. (2)
      ii. Compare these **TWO** approaches in terms of efficiency and response *time*. (2)
      iii. Mention **ONE** scenario where interrupts might be required in this manufacturing system. (1)
   d. The system relies on an interrupt handler to process interrupts generated by the actuators. Outline the role of an interrupt handler when processing interrupts and its relationship with the system stack during execution. (3)
   e. Multiple interrupts may occur simultaneously in the system. Mention and describe **ONE** concept which might be implemented to handle multiple interrupts efficiently. (2)
   f. Define the role of an Interrupt mask register and explain its role in managing interrupts. (2)

(Total: 20 marks)

7. A software development team wants to design an application that can run seamlessly on multiple platforms, including desktops, mobile devices, and virtual environments. To achieve this, the team must evaluate different language translators, compilers, and execution environments to optimise the development and runtime performance of their application.

    a. Programming languages must be translated before a computer can execute them. Describe the role of a language translator in this process and explain why translation is necessary for a computer system to function correctly. (3)
    b. State **ONE** advantage of translating a program before execution and **ONE** advantage of translating a program while it is running. (2)
    c. Explain why some programming languages require multiple stages of translation. (1)
    d. The software development team is mostly comfortable working with compilers over interpreters.
        i. Explain why this might be the case. (1)
        ii. Mention and describe **THREE** types of compilers. (3)
    e. During program execution, optimising translation techniques can improve efficiency.
        i. Explain the role of lexical analysis in the compilation process. (2)
        ii. Provide **TWO** benefits of performing syntax analysis before code execution. (2)
    f. Virtual machines can play an important role in making the application platform-independent.
        i. Define the concept of a virtual machine and describe how it supports platform independence. (2)
        ii. Discuss **TWO** advantages and **TWO** challenges of using a virtual machine in a development environment. (4)

(Total: 20 marks)

8. Imagine you are a developer, creating a Java program to manage student records. The program will store names and grades in an array, process the data using loops, and save the information to a file for future use. Answer the following questions based on this scenario.

    a. Define what an array is and explain its purpose in Java programming. (2)
    b. Write a Java code snippet to create an array of 10 student names and initialise it with string values. The suggested names are Alice, Bob, Tom, David, Eve, Frank, Jane, Mary, Rita and Peter. (3)
    c. Explain the differences between the while, do-while, and for loops in Java. Referring to the scenario of this question, provide **ONE** example where the while loop might be used and **ONE** example where the do-while loop might be used. (4)
    d. Write a Java code snippet to iterate through the array of student names created in part (b) and display each name using a for loop. (2)
    e. Explain the difference between text files and object files in Java. (2)
    f. Write a Java code snippet to create a text file named 'StudentGrades.txt', write the student names and grades into the file, and then read the contents back from the file. (5)
    g. Mention **ONE** advantage and **ONE** disadvantage of storing data in a text file compared to an object file. (2)

(Total: 20 marks)