L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE
EXAMINATIONS BOARD

ADVANCED MATRICULATION LEVEL
2025 SECOND SESSION

SUBJECT:	**Computing**
PAPER NUMBER:	I
DATE:	29th August 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. Using the Karnaugh map technique, determine a minimised Boolean expression for the following function, **F**, given by the truth table below. Make sure to show all your working steps.

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

(Total: 5 marks)

Please turn the page.

2. A full adder is a combinational circuit that adds three binary digits: A, B and a carry input. It produces a Sum and a Carry output.

   a. Write the complete truth table showing all possible input combinations and the corresponding outputs for Sum and Carry. (2)
   b. Based on the truth table, describe the logic gates that would be used to implement the full adder circuit. (3)

(Total: 5 marks)

3. Assembly language instructions use various addressing modes to access data. For **each** of the following assembly instructions, identify and name the addressing mode used.

   a. `ADD AX, 0F000H ; Add 0xF000 to register AX` (1)
   b. `SUB DX, AX ; Subtract the contents of AX from DX` (1)
   c. `MOV DX, [BX] ; Load DX from memory at BX` (1)
   d. `MOV DX, [BX+DI] ; Load DX from memory at BX+DI` (1)
   e. `MOV [31F0H], AX ; Load AX into the memory address 0x31F0` (1)

(Total: 5 marks)

4. When writing a program in assembly language, several tools are involved in converting human-readable code into a format that the machine can execute. Provide a clear and concise explanation for **each** of the following components, describing its role in the assembly and execution of a program.

   a. Explain the role of an assembler in the programming process. (1)
   b. Define a linker and describe its function in preparing a program for execution. (2)
   c. Describe the function of a loader and how it contributes to running a program. (2)

(Total: 5 marks)

5. Data transmission can occur over various physical and wireless media. Answer the following questions based on your knowledge of transmission technologies.

   a. Name **THREE** different types of cables commonly used for data transmission. (3)
   b. Apart from cables, identify **ONE** other transmission medium used in networking, and explain how it works, giving an example of its use. (2)

(Total: 5 marks)

6. The Internet supports a variety of applications and requires specific systems to locate and connect to resources.

   a. Briefly describe **TWO** common types of Internet applications. (2)
   b. Explain the process of how a URL is translated into an IP address in order to locate and establish a connection with the appropriate web server on the internet. (2)
   c. Explain why it is more convenient and user-friendly to use a URL instead of an IP address when accessing a website through a web browser. (1)

(Total: 5 marks)

7. In the software development process, several tools and techniques are used to design and visualize the structure and flow of a program before implementation.

   a. During which stage of the Software Development Life Cycle (SDLC) are Jackson Structured Programming (JSP) and Flowcharts typically used? (2)
   b. Using the appropriate JSP diagram symbols, draw the following basic control structures:
      i. a sequence (1)
      ii. a selection (decision) (1)
      iii. an iteration (loop) (1)

(Total: 5 marks)

8. The Waterfall Model and Rapid Application Development are two widely used approaches to software development.

   a. Briefly explain the main difference between the Waterfall Life Cycle model and Rapid Application Development (RAD). (2)
   b. Describe the Implementation stage of the Waterfall model by highlighting the key activities that take place during this stage. (3)

(Total: 5 marks)

9. Consider the following Patient table:

patient_code	name	phone_no	year_of_birth	health_condition	released
1001	Alice Micallef	21221212	1975	asthma	no
1002	Brian Camilleri	21334567	1982	diabetes	yes
1003	Claire Vella	21445566	1990	thyroid	no
1004	David Galea	21556677	1985	cholesterol	no
1005	Emma Farrugia	21667788	1992	thyroid	yes
1006	Frank Sciberras	21778899	1968	hypertension	yes

Using the above table, answer the following SQL-related questions. Present your answers in table format, as they would appear when the query is executed.

a.
```
SELECT name, phone_no
FROM Patient
WHERE health_condition = 'thyroid'
ORDER BY name;
```
(2)

b.
```
SELECT patient_code, name
FROM Patient
WHERE released = 'no' AND year_of_birth > 1980;
```
(3)

(Total: 5 marks)

Please turn the page.

10. A Database Management System provides various tools and features to efficiently manage, design and maintain databases.

    a. List **TWO** tools or features that are commonly provided with a Database Management System. (2)
    b. Briefly explain **TWO** drawbacks of using a relational database system. (2)
    c. Define data dictionary in the context of databases. (1)

(Total: 5 marks)

11. As part of a project to improve the efficiency of a computer system, you are analysing how the System Bus facilitates communication between components, with particular emphasis on the Data Bus.

    a. Briefly define the purpose of the Data Bus. (1)
    b. Explain how the Data Bus interacts with the Address Bus and Control Bus to facilitate communication. (1)
    c. Explain the difference between synchronous and asynchronous data transfer. Provide **ONE** example where asynchronous data transfer is preferable. (2)
    d. Using your understanding of how the buses communicate, describe the steps involved in a memory write cycle. (1)

(Total: 5 marks)

12. Memory plays a critical role in computer systems, with different types of RAM offering specific advantages depending on performance, capacity, and power consumption requirements.

    a. Describe the following **TWO** types of RAM:
        i. static RAM;
        ii. dynamic RAM. (2)

    b. For **each** of the following scenarios, identify the most suitable type of RAM and justify your choice:
        i. A high-speed cache memory for a CPU.
        ii. A computer's main memory for running multiple applications.
        iii. A memory solution for a portable device where power consumption must be minimised. (3)

(Total: 5 marks)

13. Imagine you are managing a multitasking system where multiple processes share resources such as printers and files. During operation, you notice that some processes are unable to proceed, potentially due to a deadlock.

    a. Define what a deadlock is and state **TWO** key conditions necessary for a deadlock to occur. (2)
    b. Provide an example of a scenario where a deadlock could occur in this multitasking system you are managing. (1)
    c. Describe **ONE** method to detect a deadlock and **ONE** method to avoid it. (2)

(Total: 5 marks)

14. As a system administrator at an insurance company, you manage a multitasking environment where multiple applications, such as claim processing, policy management, and customer data analysis, run simultaneously. Your role involves optimising memory usage and ensuring secure process execution to maintain system efficiency.

    a. Explain the purpose of a memory map in a multitasking environment. (1)
    b. Describe how a memory map differs between single-programming and multi-programming environments. (1)
    c. Explain what memory store protection is and why it is important in a multitasking environment. (1)
    d. Provide an example of how memory store protection could prevent a fault when multiple applications are running concurrently. (1)
    e. Describe **ONE** potential consequence of inadequate memory store protection in your insurance company's multitasking system. (1)

(Total: 5 marks)

15. Imagine you are working as a software engineer and part of your role is related to ensuring that interrupt handling is efficient and responsive in a computer system.

    a. Explain the purpose of interrupt handling in computer systems. (1)
    b. Describe how a computer detects the source of an interrupt and what happens immediately after an interrupt is detected. (1)
    c. Define the following terms related to interrupts and explain their roles:
        i. Interrupt Service Request (IRQ); (1)
        ii. Interrupt Service Routine (ISR). (1)
    d. Explain the function of the Interrupt Enable/Disable Register and its significance in interrupt handling. (1)

(Total: 5 marks)

16. The grammar for a simplified programming language is defined as follows:

```
<statement>  ::= <assignment> | <loop>
<assignment> ::= <variable> = <expression>
<loop>       ::= while <condition> do <statement>
<variable>   ::= x | y | z
<expression> ::= <variable> | <variable> + <variable>
<condition>  ::= <variable> > <variable>
```

    a. Explain the purpose of the meta-symbols ::=, < >, and | in the grammar above. (3)
    b. Using the grammar provided, determine whether the following statement is valid:
        while x > y do z = x + y
        Justify your answer. (2)

(Total: 5 marks)

Please turn the page.

17. Compilers play a key role in translating code, but there are specialized types of compilers with unique functions.
    a. Define the following types of compilers and explain their primary purpose:
        i. Macro preprocessor;
        ii. Cross-compiler;
        iii. P-code compiler. (3)
    b. Select **TWO** of the compilers defined in part (a) and give a specific example of when **each** might be used in software development. (2)

(Total: 5 marks)

18. The following Java code snippet is part of a simple program:

```
int a = 5, b = 10;
double c = 2.5;
boolean result;

result = (a < b) && (c > b);
System.out.println("Result: " + result);
System.out.println("Sum: " + (a + c));
```

    a. Identify **TWO** primitive data types used in the code. (1)
    b. Explain the purpose of the keywords 'print' and 'println' in Java. (2)
    c. What is the output of the code? Show your working to explain how the values are computed. (2)

(Total: 5 marks)

19. The following Java code initialises a linear list of tasks:

```
import java.util.ArrayList;

public class TaskManager {
    public static void main(String[] args) {
        ArrayList<String> tasks = new ArrayList<>();
        tasks.add("Task 1");
        tasks.add("Task 2");
        tasks.add("Task 3");
    }
}
```

    a. Name and describe **THREE** other types of lists apart from a linear list. (3)
    b. Based on the Java code provided above, write the Java code to:
        i. add a new task named 'Task 4' to the end of the list;
        ii. remove the first task from the list. (2)

(Total: 5 marks)

20. A software company is deciding which programming paradigm to use for their next project. They are unsure whether to opt for object-oriented or imperative programming.

    a. Briefly describe the key characteristics of:
        i. object-oriented programming (OOP);
        ii. imperative programming. (2)
    b. Name **TWO** other programming paradigms apart from those mentioned in part (a), and describe at least **ONE** of their key characteristics. (2)
    c. Compare object-oriented programming with imperative programming, focusing on:
        i. the need for modelling the real world;
        ii. enhancing software reusability. (1)

(Total: 5 marks)

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ADVANCED MATRICULATION LEVEL
2025 SECOND SESSION

SUBJECT:	**Computing**
PAPER NUMBER:	II
DATE:	1st September 2025
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 4-bit input (0–15) drives an LED panel with a central lamp L. In basic mode only codes 0–9 are valid; 10–15 are undefined (don't care).

   The behaviour is as follows:
   L = 1 (ON) for codes {1, 2, 3, 5, 6, 8}
   L = 0 (OFF) for codes {0, 4, 7, 9}

   a. Complete a truth table for output L, where L = 1 if the center light is ON for codes 0–9. For codes 10–15, mark the output as X (don't care). (2)
   b. Use a Karnaugh map to find a minimised Boolean expression for output L. No Boolean algebra simplification is required beyond the K-map. (4)
   c. Draw a logic circuit diagram that implements the expression from (b), using only NAND and NOT gates. (6)

   In extended mode, all 16 input values (0–15) represent valid status codes. The center light L2 should now be:
   ON for codes 1, 2, 3, 5, 6, 8, 10, 11, 13, 14
   OFF for codes 0, 4, 7, 9, 12, 15
   There are no don't care values in this mode.

   d. Add a column to the truth table from part (a) for a new output L2, where L2 = 1 if the center light is ON in extended mode. (1)
   e. Use a Karnaugh map to derive a minimised Boolean expression for L2. Do not simplify further using Boolean laws. (4)
   f. Compare the Boolean expressions for L and L2:
      i. Can the logic for L be reused in extended mode? (1)
      ii. Is the logic for L2 valid for use in basic mode? (1)
      iii. Provide a clear explanation for your conclusions. (1)

(Total: 20 marks)

Please turn the page.

2. The assembly subroutine findNextPowerOf2 is designed to find the smallest power of 2 greater than or equal to a given input value stored in register AX.

```
findNextPowerOf2:
    DEC AX                  ; Decrease AX by 1
    MOV DX, AX              ; Load AX into DX
    OR AX, DX               ; AX = AX OR DX
    MOV DX, AX              ; Load AX into DX
    SHR DX, 1               ; Shift contents of DX right by 1 bit
    OR AX, DX               ; AX = AX OR DX
    MOV DX, AX              ; Load AX into DX
    SHR DX, 2               ; Shift contents of DX right by 2 bits
    OR AX, DX               ; AX = AX OR DX
    MOV DX, AX              ; Load AX into DX
    SHR DX, 4               ; Shift contents of DX right by 4 bits
    OR AX, DX               ; AX = AX OR DX
    MOV DX, AX              ; Load AX into DX
    SHR DX, 8               ; Shift contents of DX right by 8 bits
    OR AX, DX               ; AX = AX OR DX
    INC AX                  ; Increase AX by 1
    RET                     ; Return from subroutine

start:
    MOV AX, 0F23H           ; Load AX with hex 0F23
    CALL findNextPowerOf2   ; Invoke the routine findNextPowerOf2
    MOV BX, AX              ; Load AX into BX
    MOV AX, 0400H           ; Load AX with hex 0400
    CALL findNextPowerOf2   ; Invoke the routine findNextPowerOf2

finish:
```

a. What are the final contents of registers `AX` and `BX` in hexadecimal after executing the code between start and finish? Show **all** intermediate steps of `AX` and `DX` during the subroutine calls. (10)

b. How many assembly instructions are executed during this run, including those inside the subroutine? (3)

c. Identify **TWO** types of operations performed on registers in the code, and give **ONE** example of **each**. (4)

d. Explain in your own words what the `findNextPowerOf2` subroutine accomplishes. Describe how it differs from a subroutine that finds the previous power of two. (3)

(Total: 20 marks)

3. An organisation is planning to upgrade its outdated inventory management system to improve efficiency and integration with suppliers. The system will track stock levels, handle supplier orders and generate automated reports for management.

   a. Briefly explain **TWO** specialist roles involved in a development team. (3)
   b. Briefly describe **TWO** fact-finding techniques that can be used during the requirements gathering phase and explain when each would be most appropriate. (4)
   c. Explain the purpose of a Data Flow Diagram (DFD) and draw a simple Level 0 DFD for an inventory system that processes orders and updates stock levels. (4)
   d. Explain what is meant by a feasibility study. Briefly describe **TWO** types of feasibility studies that should be considered before beginning system development. (3)
   e. Explain what is meant by prototyping in system development. Describe how it can help reduce system failure. (2)
   f. Explain **TWO** differences between logical and physical design in system development. (2)
   g. Briefly explain what is meant by system maintenance, and identify **TWO** common types of maintenance activities that may be needed after deployment. (2)

(Total: 20 marks)

4. Consider the following table, music_inventory, which contains information about the albums in a music library. The column albumID is the primary key, uniquely identifying each album. The table also records the genre of each album, the quantity available and the price of each album.

album_id	genre_id	genre	quantity	price_euro
1	1	Rock	3	14.99
2	2	Jazz	1	19.99
3	2	Jazz	2	22.99
4	3	Classical	5	9.99
5	1	Rock	4	12.99

   a. Normalise the given table to Third Normal Form (3NF). For **each** table in your final 3NF schema, identify its primary key. (5)
   b. If the table were left unnormalised, mention what issues could arise with data integrity. (2)
   c. Does the table, in its current form, allow an album to have more than one price? Justify your answer. (2)

   The music library is now planning to expand to multiple locations and needs the database to track the inventory per location, rather than maintaining a single centralised collection.

   d. Based on the normalised design from part (a):
      i. Describe any new tables that should be created to track inventory per location. (6)
      ii. Explain the modifications that should be made to represent the quantity of albums available at **each** location. (5)

(Total: 20 marks)

Please turn the page.

5. The CPU relies on various special internal registers and cache memory to optimise performance and execute instructions efficiently.

   a. One of the internal registers in a CPU is the stack register.
      i. Explain what the stack register is used for and describe its purpose in the CPU. (2)
      ii. Provide **ONE** example of how the stack register is used during the execution of a function. (1)
   b. Another important CPU register is the status/flag register.
      i. Describe the role of the status/flag register in the CPU. (2)
      ii. Provide **ONE** example of how the status/flag register affects the execution of instructions in a program. (1)
   c. List and explain the purpose of **FOUR** CPU internal registers, excluding the stack register and status/flag register. (6)
   d. In addition to registers, cache memory is an essential component of the CPU.
      i. Define cache memory and explain its purpose. (2)
      ii. Differentiate between Level 1 (L1) and Level 2 (L2) cache. (2)
      iii. Compare cache memory and CPU registers in terms of:
         1. access speed;
         2. system performance. (2)
      iv. Provide **TWO** examples where cache memory significantly enhances the performance of demanding applications. (2)

(Total: 20 marks)

6. Consider the following Java code snippet, which must be converted from source code to executable machine code:

```
int x = 10
int y = z + 5;
if (y > 10) {
    System.out.println("Value is greater than 10");
} else {
    System.out.println("Value is 10 or less");
}
```

   a. Explain the purpose of lexical analysis in the compilation process and describe **THREE** tasks performed during this stage. (4)
   b. Identify **FOUR** possible tokens generated during lexical analysis of the provided code. (2)
   c. Explain the roles of syntax and semantic analysis in the compilation process. (2)
   d. Describe the purpose of a symbol table during the semantic analysis process. (1)
   e. List **TWO** possible entries that would be added to the symbol table for the provided code. (2)
   f. Identify **ONE** syntax error and **ONE** semantic error in the provided code, and explain how **each** would be detected. (4)
   g. Explain the purpose of code optimisation. (1)
   h. Describe **TWO** techniques used to improve the efficiency of generated code. (2)
   i. Optimise the following part of the provided code and explain your changes:

```
if (y > 10) {
    System.out.println("Value is greater than 10");
} else {
    System.out.println("Value is 10 or less");
}
```

(2)

(Total: 20 marks)

7. A software developer is tasked with implementing efficient sorting algorithms, managing dynamic data structures, and controlling program flow in a project involving data processing.

   a. The developer is asked to implement a basic sorting algorithm. Write a pseudocode implementation of the 'Bubble Sort' algorithm. (4)

   b. Next, the developer needs to analyse a more advanced sorting algorithm. Dry-run the following 'Quick Sort' algorithm on the array [8, 3, 6, 4]. Show the state of the array after each step. (6)

```
QuickSort(arr, low, high)
    if low < high:
        pivotIndex = Partition(arr, low, high)
        QuickSort(arr, low, pivotIndex - 1)
        QuickSort(arr, pivotIndex + 1, high)

Partition(arr, low, high)
    pivot = arr[high]
    i = low - 1
    for j = low to high - 1:
        if arr[j] <= pivot:
            i = i + 1
            Swap arr[i] and arr[j]
    Swap arr[i + 1] and arr[high]
    return i + 1
```

   c. While implementing sorting algorithms for large datasets, the developer considers using pointers for efficiency. Describe what a pointer is and explain its use in conjunction with dynamic arrays during sorting. (2)

   d. Provide **ONE** example of the pseudocode used to swap two elements in an array during Quick Sort. (2)

   e. The developer wants to add logic to enhance the sorting process. Write a pseudocode snippet demonstrating a 'nested if-else' structure to determine the position of the smallest element in an array for use in Selection Sort. (3)

   f. Write a Java snippet demonstrating a 'switch' statement that prints which sorting algorithm to use based on user input (1 for Bubble Sort, 2 for Quick Sort). (3)

(Total: 20 marks)

Please turn the page.

8. A technology consultant has been tasked with evaluating different operating systems and memory management strategies for various applications.

   a. Mention **FOUR** types of operating systems and describe them. (6)
   b. For **each** operating system mentioned in part (a), provide a relevant scenario or example where it would be the most suitable choice. (4)
   c. During the evaluation, the consultant explores how operating systems manage processes.
      i. Define the term 'process control operations'. (1)
      ii. Provide **TWO** examples of process control operations. (2)
   d. To handle specific tasks, the consultant considers the use of Job Control Language (JCL). Explain the purpose of JCL and how it is applied in operating systems. (2)

   The consultant then examines memory management strategies.

   e. Explain the difference between logical and physical address spaces in memory management. (2)
   f. Explain what happens when a logical address is converted to a physical address during program execution. (1)
   g. Define 'relocate-ability' in the context of memory usage, and explain why it is important in modern operating systems. (2)

(Total: 20 marks)