

SUBJECT:	Computing
PAPER NUMBER:	I
DATE:	29 th August 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. Binary numbers and their various representations are fundamental in digital logic.

- a. Convert the decimal number 25 to an 8-bit binary number. (1)
- b. Perform the binary addition of the following 4-bit unsigned integers: 1101 and 1010.
Show your working. (2)
- c. Explain the concept of overflow in binary arithmetic and provide an example. (2)

(Total: 5 marks)

2. Logic gates, truth tables, and combinational logic circuits constitute the fundamental building blocks in the realm of digital logic design, forming the cornerstone upon which complex digital systems are constructed and engineered.

- a. Draw the truth table for a 3-input AND gate. (1)
- b. Simplify the following Boolean expression using Boolean algebra theorems.
 $\bar{A} + A.B$ (2)
- c. Create a logic circuit using AND, OR and NOT gates for the following Boolean function.
 $F = \bar{A}.B + A.\bar{B}$ (2)

(Total: 5 marks)

3. The assembly process typically involves several sequential steps, each critically important for efficiently converting assembly code into fully functional executable programs.

- a. Briefly explain the **FOUR** main steps of the assembly process: assembling, linking, loading, and relocation. (2)
- b. What is the purpose of a cross assembler? (1)
- c. Define macro assemblers and explain how they differ from standard assemblers. (2)

(Total: 5 marks)

Please turn the page.

4. Interpreting assembly programs requires a good understanding of instruction formats and the functions of various instructions.

- a. Given the following assembly instruction: `ADD AX, BX`. Explain what this instruction does. (1)
- b. Interpret the following code fragment and describe its function.

```
MOV AX, 0005H ; Move the hexadecimal value 0005 into register AX
MOV BX, 0003H ; Move the hexadecimal value 0003 into register BX
ADD AX, BX    ; Add the value in BX to AX
SUB AX, 0002H ; Subtract the hexadecimal value 0002 from AX
```

- (2)
- c. Explain the difference between `MOV` and `ADD` instructions in assembly language, and give an example of **each**. (2)

(Total: 5 marks)

5. A comprehensive understanding of Internet Protocol (IP) addressing and Internet protocols is essential for effectively navigating the complexities of modern network communication systems.

- a. Define IP address and discuss its usage, including the need for public IPs and private IPs. (2)
- b. Explain the differences between IPv4 and IPv6 protocols, highlighting at least **THREE** format differences and their implications. (3)

(Total: 5 marks)

6. Network security is paramount in safeguarding information and infrastructure.

- a. Define network security and distinguish between logical and physical security measures. Provide examples of **each**. (2)
- b. Explain encryption and distinguish between Public and Private Keys. (2)
- c. Discuss the use of digital signatures and digital certificates in network security. (1)

(Total: 5 marks)

7. The regular maintenance of systems plays a pivotal role in ensuring the sustained longevity and optimal performance of software solutions over time.

- a. Define adaptive maintenance and provide an example. (1)
- b. Explain the difference between corrective and perfective maintenance, providing examples for **each**. (2)
- c. Discuss the various tasks involved in effectively maintaining system documentation and explain why this practice is crucial. (2)

(Total: 5 marks)

8. System modelling is a crucial aspect of system analysis and design.
- Explain the process modelling and data flow-based modelling techniques. (2)
 - Describe how Unified Modelling Language (UMLs) diagrams help system analysts model various parts of a software solution. (1)
 - Define Entity-Relationship Diagrams (ERDs) and explain their basic use. (2)

(Total: 5 marks)

9. Database administration involves various tasks to maintain and optimise the performance of a database system.
- Outline **THREE** tasks performed by a database administrator to ensure the smooth operation of a database system. (3)
 - Discuss the importance of backup and recovery procedures in database administration and describe the strategies used for data backup and restoration. (2)

(Total: 5 marks)

10. Tables are fundamental components of relational databases, organising data into rows and columns. Consider the following table named "Employees":

EmployeeID	FirstName	LastName	Department	Salary
1	John	Doe	Sales	50000
2	Jane	Smith	Marketing	55000
3	Alice	Johnson	HR	48000
4	Bob	Williams	IT	60000
5	Emily	Brown	Finance	52000

- Explain the purpose of the "Employees" table in a relational database. (2)
- Identify the primary key of the "Employees" table and explain its significance. (2)
- Provide the result obtained by executing the following SQL query:

```
SELECT FirstName, LastName, Salary
FROM Employees
WHERE Salary > 52000;
```

(1)

(Total: 5 marks)

Please turn the page.

11. Suggest a kind of memory device (RAM, ROM, etc) that is suitable for each of the following scenarios:
- An algorithm requires a very large data set consisting of fixed numbers, that is, constants that do **not** need to be updated. Millions of devices that run the algorithm are to be produced. (1)
 - The firmware program of a consumer device is stored in the device memory. Every few weeks, the firmware needs to be updated. Millions of devices are to be produced. (1)
 - An algorithm requires a similar very large data set consisting of fixed numbers. This time, only a few tens of devices that run the algorithm are required. (1)
 - A developer needs to store the firmware program for a development board on the board's memory. The program will need to be updated many times and the firmware cannot be lost when the board is switched off. (1)
 - An application produces a large amount of data in a short time. As soon as the data is produced, some algorithms will make use of it and the data can be discarded. (1)

(Total: 5 marks)

12. Create a BNF grammar for a simplified calculator that can handle basic arithmetic expressions. The expressions can consist of:
- Single digits (0-9)
 - The addition operator (+)
 - The subtraction operator (-)

The following are examples of valid expressions:

- 3+4
- 7-2
- 1+1
- 9-3+7

(Total: 5 marks)

13. A company is planning to implement several systems and needs to select the appropriate Operating System (OS) for each one.
- Based on the scenarios below, identify the most appropriate type of OS for each case and briefly justify your choice.
 - The company processes employee payrolls at the end of each month. This involves calculating salaries and generating pay slips for all employees. (1)
 - The company needs a system that allows all employees to share files, communicate internally, and access common resources regardless of their physical location. (1)
 - The company operates a manufacturing line where machinery must respond instantly to changes in the production process to avoid defects. (1)
 - The company wants to provide a platform where customers can log in, raise support tickets, and receive immediate assistance. (1)
 - Explain in which scenario above, a Job Control Language (JCL) is likely to be used, and why. (1)

(Total: 5 marks)

14. A programmer is tasked with implementing the “back” button on an Internet browser, which allows users to go back to previous pages that they visited during their browsing session.
- Select and justify an appropriate data structure for the functionality of the “back” button. (2)
 - Explain how each operation of this data structure will operate in the context of the “back” button. (2)
 - Identify **ONE** disadvantage of using this data structure in an Internet browser. (1)

(Total: 5 marks)

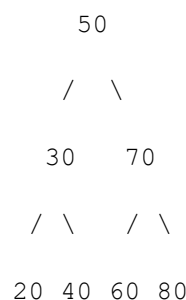
15. A simple microprocessor for a basic calculator is being designed. The calculator needs to perform the following operations: addition, subtraction, multiplication, and division. What components are typically included in microprocessor design, and what is the role of each one in the context of the basic calculator?

(Total: 5 marks)

16. In a power station, a computer monitors the temperature of various generators throughout the plant. It is responsible for continuously checking sensors on generators and updating a screen with the latest temperature readings. Should the temperature of any particular generator rise above a certain threshold, an alarm should sound immediately, and the system pauses until an engineer reviews the situation.
- Name and describe **TWO** different process scheduling algorithms that could be used here. (2)
 - Explain how these scheduling algorithms would work together in this particular case. (2)
 - Propose **ONE** scenario that could happen which result in a system malfunction. (1)

(Total: 5 marks)

17. A library system uses a binary tree to manage and organise book IDs. Consider the following tree representing book IDs.



- Explain the concept of a binary tree. (1)
- Name and describe a traversal algorithm which would produce a list of book IDs in ascending order. (2)
- Name and describe a traversal algorithm which could be used to safely delete all the book IDs from the tree, in such a way that no nodes are orphaned in the process. (2)

(Total: 5 marks)

Please turn the page.

18.

- a. Define the expression $2(1+5) \div 3$ in Reverse Polish Notation (RPN). (1)
- b. Explain why RPN is useful when defining arithmetic expressions. (1)
- c. Use a stack to evaluate the expression obtained in part (a) of this question. (3)

(Total: 5 marks)

19. Consider the following Java code:

```
public int doSomething(int[] arr, int index) {
    if (index >= arr.length) {
        return 0;
    } else {
        return arr[index] + doSomething(arr, index + 1);
    }
}
```

- a. Explain the purpose of this method. (1)
- b. What programming technique is being used in this code? (1)
- c. Produce an alternative version of this code that does **not** use the programming technique identified in part (b). (3)

(Total: 5 marks)

20. Consider the following Java method:

```
public int calculate(int num1) {
    return num1 * num1;
}
```

- a. Overload the method to take a second parameter of type `int` and return the sum of the two parameters. (2)
- b. In part (a), overloading was performed by adding a second parameter. Explain how one could overload a method without changing the number of parameters. (1)
- c. Two classes, `BinaryCalculator` and `DecimalCalculator` both inherit from a `Calculator` class and implement a `printResult()` to display the result of the most recent calculation in binary and decimal formats respectively. Name and explain a mechanism for ensuring that the `printResult()` method is implemented in both subclasses. (2)

(Total: 5 marks)



SUBJECT:	Computing
PAPER NUMBER:	II
DATE:	30 th August 2024
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. DigiLogic Inc. specialises in designing digital circuits for various applications. The company has been tasked with designing a set of digital logic components for a new line of products. These components will involve binary arithmetic, data storage, logic gates, and Boolean algebra. The goal is to ensure the designs are efficient, error-free, and meet the specified requirements.

- DigiLogic Inc. needs to implement a system that uses both signed and unsigned integers for different calculations. Explain how computers represent and manipulate the following types of numbers. Provide an example for **each** type using 8-bit representation.
 - Unsigned integers; (2)
 - Signed integers using two's complement; (2)
 - Binary Coded Decimal (BCD). (2)
- Perform the following binary arithmetic operations and explain any overflow or underflow that occurs. Use 8-bit Two's complement representation for the signed operations.
 - $01010101 + 00110011$ (2)
 - $11001001 - 01100110$ (2)
- Convert the following data storage units and explain the importance of understanding these conversions in digital systems.
 - 2048 bytes to kilobytes (KB) (1)
 - 3 gigabytes (GB) to megabytes (MB) (1)
 - 5 terabytes (TB) to gigabytes (GB) (1)
- DigiLogic Inc. is designing a combinational logic circuit. Draw the truth table and the corresponding logic circuit for the following Boolean function. Then simplify the Boolean expression using Boolean algebra theorems.

$$F(A, B, C) = (A \cdot B) + (A \cdot C) \quad (3)$$
 - Explain the concept of the universality of NAND and NOR gates. (2)
 - Design a simple circuit that implements the following Boolean expression using only NAND gates.

$$F(A, B) = A + B \quad (2)$$

(Total: 20 marks)

Please turn the page.

2. TechWave Corporation is planning to set up a new state-of-the-art office building with a comprehensive and advanced network infrastructure. The building will house various departments, including Administration, Marketing, Research and Development, and Customer Support. The company wants to ensure high-speed connectivity, minimal interference, and robust error detection mechanisms throughout the network. They also plan to implement various network topologies for different segments of their network to ensure efficient, reliable, and secure communication across all departments.
- a. TechWave Corporation is considering different types of network media for their new office building. Compare and contrast the following network media types in terms of maximum length, speed, and immunity to Electro-Magnetic Interference (EMI). Suggest the ideal situations for using **each** type.
 - i. Coaxial (2)
 - ii. Twisted pair (including shielded and unshielded) (2)
 - iii. Fibre optic (2)
 - iv. Wireless (Satellite, Bluetooth, and Wi-Fi) (2)
 - b. Define EMI and noise, and discuss how they can affect data transmission in the office network. (2)
 - c. Explain the use of Parity and Checksum checks as error detection and correction measures. Describe when and where it would be best to apply **each** method in the context of TechWave Corporation's network. (4)
 - d. TechWave Corporation plans to implement different network topologies for various departments. Compare and contrast the following network topologies, providing diagrams for **each**. List at least **TWO** advantages and **TWO** disadvantages for **each** topology.
 - i. bus; (2)
 - ii. mesh; (2)
 - iii. point-to-point. (2)

(Total: 20 marks)

3. TechSolutions Ltd. is a company specialising in developing software solutions for retail businesses. They have been contracted to develop an inventory management system for a medium-sized retail store. The system should handle product information, stock levels, supplier details, and sales transactions. The project requires thorough system analysis and design to ensure it meets all the client's needs.
- a. TechSolutions Ltd. has conducted an initial analysis and has identified the main processes for the inventory management system. The processes include: Manage Products, Process Sales, Manage Suppliers, and Generate Reports. Create a Level 1 Data Flow Diagram (DFD) for the inventory management system based on these processes. Make sure to include data stores for Product Information, Sales Transactions, and Supplier Details, and relevant data flows. (5)
 - b. Explain the importance of using Data Flow Diagrams (DFDs) in system analysis and describe how they help in understanding and documenting system requirements. (2)
 - c. Create a Use-Case Diagram (UCD) for the inventory management system. The diagram should include the following actors: Store Manager, Sales Clerk, Supplier. (4)
 - d. Explain how UCDs assist in determining system requirements and communicating them to stakeholders. (2)
 - e. TechSolutions Ltd. is considering a modular design for the inventory management system. List **THREE** advantages of using a modular design in system development. (3)

- f. The company needs to decide on an implementation strategy for the new system. Compare and contrast the following changeover techniques.
- i. direct changeover; (2)
 - ii. phased implementation. (2)

(Total: 20 marks)

4. Understanding various aspects of database systems, including DBMS structures, relational databases, SQL, Entry-Relationship (E-R) modelling, and normalisation, is essential for effective database design and management.
- a. Explain the structure and function of a database management system (DBMS). Discuss the roles of the data dictionary, data manipulation language (DML), data description language (DDL), query language, and security features within a DBMS. (5)

StudentID	FirstName	LastName	DateOfBirth	Major
101	Alice	Smith	2000-01-15	CS
102	Bob	Brown	1999-05-23	Maths
103	Charlie	Johnson	2001-09-10	Physics
104	Diana	White	2000-11-25	CS
105	Eva	Green	2002-07-30	Maths

- b. Consider the above relational database table named "Students".
- i. Using short notation, represent the "Students" table, including the primary key. (2)
 - ii. Explain the purpose of each of the following SQL commands, providing an example how you might use it in the table above. There is no need to produce SQL statements in your example, but rather an explanation of a scenario and how the command in question would help.
 - **HAVING**: Differentiate it from WHERE and provide a demonstrative scenario. (1)
 - **GROUP BY**: Describe its purpose and provide a demonstrative scenario. (1)
 - **JOIN**: Explain how it is used to combine rows from different tables. (1)
 - iii. Given the following SQL query, describe what the query does and provide the result.


```
SELECT FirstName, LastName, Major
FROM Students
WHERE Major = 'CS'
ORDER BY LastName;
```

 (3)
- c. Describe the importance of E-R modelling in database design. Explain the "Crow's Foot" notation used in E-R diagrams, and provide an example. (3)
- d. Explain the process and importance of normalising a database. (1)

Please turn the page.

- e. Normalise the following table up to the Third Normal Form (3NF). (3)

OrderID	CustomerName	ProductID	ProductName	Quantity
1	John Graham	101	Smartphone	4
2	Jane Smith	102	Laptop	2
3	John Graham	103	Tablet	5
4	Alice Brown	101	Smartphone	3
5	Jane Smith	104	Smartwatch	1

(Total: 20 marks)

5.

- a. Describe the processor's fetch-execute cycle. Your answer should include details of how the Program Counter (PC), Memory Address Register (MAR), Memory Data Register (MDR) and Current Instruction Register (CIR) are used in this context. (8)
- b. For each of the assembly instructions, state whether the instruction in question modifies the PC during its execution:

Instruction	Description
push	Push a word onto the stack.
jc	Jump if the carry flag is set.
call	Call a function.
stc	Set the carry flag.

(2)

- c. A memory device is connected to a processor via the data lines, address lines and control lines. Describe the read cycle, that is how the processor reads a word from the memory device. Your answer should include details of how the data lines, address lines and control lines are used during the read operation. (4)
- d. A processor has a 32-bit wide address bus and uses byte addressable memory. The processor makes use of memory mapped I/O addressing and dedicates 500Mb of address space to the I/O subsystem. Explain how:
- an approximation from the total address space that can be accessed using a 32-bit wide address bus is determined. Hint: 2^{10} is approximately equal to 1000, 2^{20} is approximately equal to 10^6 , ... (3)
 - the size of the address space dedicated to memory access is determined. (1)
 - an approximation for the percentage of the address space dedicated to I/O is determined. (2)

(Total: 20 marks)

6. The National Library houses thousands of publications of different types including manuscripts, books, magazines and newspapers. All publications are assigned a unique identifier, a title and a year of publication. However, the library requires specific types of information for each type of publication:

- Manuscripts might be fragile, so the library needs to know if that is the case;
- Books require an ISBN number;
- Magazines have a category which can contain "Leisure", "Professional" or "Sports";
- Newspapers require information about which month and day they were published.

The library is developing a computerised system for storing information about publications and have designed the following class to represent publications:

```
public class Publication {
    String publicationType;
    String id;
    String title;
    int yearOfPublication;
    int monthOfPublicationForNewspapers;
    int dayOfPublicationForNewsPapers;
    boolean isFragileForManuscripts;
    int isbnForBooks;
    String categoryForMagazines;
    public String getPublicationType() {
        return publicationType;
    }
}
```

- a. Mention **ONE** disadvantage present in the class above. (1)
- b. Which OOP technique can be used to solve this issue? (1)
- c. Produce a class diagram which uses the technique mentioned in part (b) to produce a better representation of publications for the library. Ensure that the `getPublicationType()` method cannot be called from the current `Publication` class. (6)
- d. The librarian wants to maintain a list of publications but does not know the maximum number of publications she will have in future. Which Java data structure can be used to store the list of publications? (1)
- e. Write the code for a class called `Library`, which uses the data structure from part (d) to maintain a list of publications. It should include the following methods:
 - i. a constructor with no parameter which initialises the data structure; (2)
 - ii. a method called `addPublication()` which takes a publication as a parameter and adds it to the library; (2)
 - iii. a method called `countPublications()` which returns the number of publications currently in the library. (2)
- f. Assuming that a method in the `Publication` class called `getPublicationType()` returns "manuscript", "book", "magazine" or "newspaper", overload `countPublication()` to return the number of publications matching the type passed in as a parameter to the method. (5)

(Total: 20 marks)

Please turn the page.

7. A new programming language is being developed. In this language, each statement is separated by a semicolon (;). The company requires help developing a metalanguage equivalent of a print statement, which must obey the following rules:
1. a print statement must start with the keyword "print";
 2. it must be followed by an expression within parentheses (brackets);
 3. the expression can either be a number or an identified (variable name);
 4. the statement must end with a semicolon.

The following are two examples of a valid print statement:

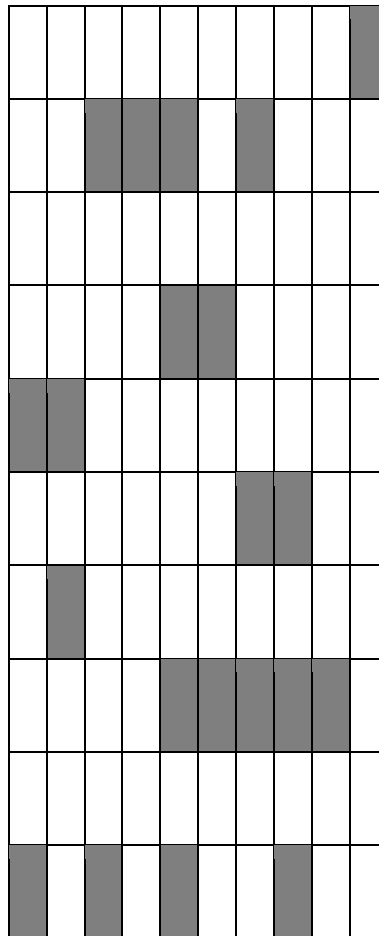
```
print(x);
```

```
print(162);
```

- a. Define the term metalanguage in the context of computer languages. (1)
- b. Using Backus-Naur form (BNF) notation, define the syntax of the print statement described above. (5)
- c. Define the main purpose of a parse tree. (1)
- d. Generate a parse tree for the following print statements: ``print(123);`` and ``print(x);`` (4)
- e. Name and briefly describe **THREE** methods of code optimisation. (3)
- f. Using different types of optimisation, perform an optimisation on the following snippets of Java code:
 - i. `x = 29+c-2;` (1)
 - ii. `a = 45;`
`b = 12;`
`for (int i=0; i<2; i++) {`
`c = i*Math.cos(a)/Math.cos(b);`
`}` (3)
 - iii. `int x = 10;`
`if (x > 5) {`
`System.out.println(x);`
`}` (1)
 - iv. `for (int i=0; i<3; i++) {`
`System.out.println("Hello");`
`}` (1)

(Total: 20 marks)

8. Consider the following representation of memory storage inside a computer. The shaded blocks correspond to utilised memory, while the empty spaces correspond to unused memory:



- a.
- i. Name and describe the issue that is shown in the memory space above. (2)
 - ii. Why is this a problem for the operating system (OS)? (2)
 - iii. Name and describe the process by which the OS would resolve this issue. (4)
- b. A particular OS uses a paging system for memory management. The physical memory is 64KB and the page size is 4KB.
- i. Explain the concept of paging in OSs, including **TWO** advantages. (4)
 - ii. Calculate the number of pages needed to cover a process that requires 20KB of memory. Show your working. (2)
 - iii. Given the page size and the physical memory size specified, calculate the total number of page frames available in the system. Show your working. (2)
- c. Describe **FOUR** mechanisms for protecting files against unauthorised access. (4)

(Total: 20 marks)