

061306T4CPM

COMPUTER PROGRAMMING LEVEL 6

IT/OS/CP/CR/02/6

Apply Discrete Mathematical Concepts

November /December 2025



**TVET CURRICULUM DEVELOPMENT, ASSESSMENT AND CERTIFICATION
COUNCIL (TVET CDACC)**

WRITTEN ASSESSMENT

Tim

INSTRUCTIONS TO CANDIDATE

1. Marks for each question are indicated in the brackets.
2. The paper consists of **TWO** sections: **A** and **B**.
3. Answer **ALL** questions in section A and **ANY THREE** (3) questions in section B.
4. Candidates are provided with a separate answer booklet
5. **DO NOT** write on this question paper.

This paper consists of FIVE (5) printed pages

Candidates should check the question paper to ascertain that all pages are printed as indicated and that no questions are missing.

SECTION A: (40 Marks)*(Answer ALL questions in this section)*

1. During a digital electronics workshop, a trainee is asked to describe Boolean Algebra, giving at least one real-world application area.

Explain the term Boolean Algebra and state one real world example. (3 marks)

2. A logistic company models delivery locations as sets.

$$\text{Let } U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}, \quad A = \{2, 4, 6, 8, 10\}, \quad B = \{1, 2, 3, 4, 5\}.$$

Find:

- i. $A \cap B$ (1 mark)
- ii. $A \cup B$ (1 mark)
- iii. $A - B$ (1 mark)
- iv. B^c with respect to U (2marks)

3. Given the following matrix:

$$X = \begin{bmatrix} 2 & 1 \\ 3 & 4 \end{bmatrix} \quad Y = \begin{bmatrix} 2 & 1 \\ 3 & 4 \end{bmatrix}$$

- i. Compute $X+Y$. (2 marks)
 - ii. Compute XY . (3 marks)
4. Convert the following number representations (6 Marks)

a. 11110111_2

b. $1AB_{16}$

c. 551_{10}

5. For $f(x)=2x+1$,

find $f(3)$ and $f(-2)$. (2 marks)

6. A manufacturing company has installed digital security systems that make use of both NOR and XNOR logic gates. Describe how the gates can be applied in enhancing security within the company. (2 marks)

7. Consider relation $R = \{(1, 1), (2, 2), (3, 3), (2, 3), (3, 2)\}$ on $A = \{1, 2, 3\}$. Determine whether:

- i. R is reflexive (2 marks)
- ii. R is transitive (2 marks)

8. In a college, the universal set U , represents all 200 students. Out of these, 120 students are in the Music Club (set M). Using the concept of set complement,

- a. Determine how many students are not in the Music Club. (2 mark)
- b. Explain the role of the universal set in this context. (2 mark)

9. A sequence is defined recursively as follows:

$$a_0 = 3, a_{n+1} = 3a_n - 2 \text{ for } n \geq 0$$

Calculate: a_1 , a_2 and a_3 .

(3 marks)

10. In a level 6 class; 8 trainees play football, 5 play hockey, and 6 play rugby. 3 play both football and hockey, 2 play both football and rugby, 4 play both hockey and rugby. 2 play all the games, and 3 do not participate in any game.

- a. Represent the above information in a Venn diagram.

(4 marks)

- b. Calculate the total number of students in the class.

(2 marks)

SECTION B: (60 Marks)

(Answer Any THREE questions in this section)

11. a. A cloud service provider monitors servers using a system that assigns each server a unique ID and tracks its status. The server statuses are represented by the function $g: S \rightarrow T$, where

$$S = \{201, 202, 203, 204\} \text{ (server IDs)}$$

$$T = \{\text{Active, Idle, Down}\} \text{ (server statuses)}$$

$$g(201) = \text{Active}, g(202) = \text{Idle}, g(203) = \text{Active}, g(204) = \text{Down}$$

- i. List all the statuses currently in use by the servers (i.e., determine the range of g). (4 marks)
 - ii. Determine whether the function g is one-to-one. Justify your answer. (4 marks)
- b. A company tracks machine output using: $P_n = P_{n-1} + 5$, $P_1 = 20$.
- i. Find P_2 , P_3 , P_4 , P_5 . (4 marks)
 - ii. Derive a formula for P_n (4 marks)
- c. A computer network is expanding such that the number of connections each month is three times the number of connections in the previous month. If the network

begins with 5 connections in the first month, calculate the total number of connections in the 8th month. (4 marks)

12. a. Determine the inverse of matrix M, showing all steps. (10 marks)

$$M = \begin{bmatrix} 5 & 2 & 1 \\ 4 & 7 & 3 \\ 6 & 2 & 8 \end{bmatrix}$$

- b. In an industrial alarm control system, X is the master enable signal (1 = system enabled), Y be the manual alarm switch (1 = manual alarm ON), and Z be the smoke detector output (1 = smoke detected). The siren output is given by the Boolean expression : $F = X(Y'Z + YZ) + XY$. Simplify the expression showing each step clearly. (4 marks)

- c. A digital security circuit is represented by the Boolean function:

$$F = A'BC + AB'C + ABC' + ABC$$

Simplify the function using a Karnaugh Map (K-Map) and show the minimized expression. (6 marks)

13. a. A software engineer defines sequence to model system resource allocation:

$$C_0 = 2, C_1 = 5, C_n = 3C_{n-1} - C_{n-2}$$

- i. Compute C_2 , C_3 and C_4 (4 marks)
 - ii. Write the recurrence relation in terms of its first few terms. (4 marks)
- b. A city's road network can be modeled as an undirected graph. We have four locations: downtown (D), the suburbs (S), the airport (A), and the industrial park (I).
- Downtown is connected to the suburbs and the industrial park.
 - The suburbs are connected to downtown and the airport.
 - The airport is connected to the suburbs.
 - The industrial park is connected to downtown.

A delivery service wants to find a route that starts at one location, travels along every road exactly once, and returns to the starting location.

- i. Draw the Graph: Represent the road network as an undirected graph. Label the vertices as D, S, A, and I. (2 marks)

- ii. Adjacency Matrix: Create an adjacency matrix for the graph drawn in Question 1. Use the order of vertices D, S, A, I. A 1 in the matrix indicates a direct road connection, and a 0 indicates no direct connection. (4 marks)
 - iii. Explain THREE advantages of using an adjacency matrix to represent the road network for this company (6 marks)
14. a. In a training college: 50 students take Programming (P), 30 take Networking (N), 20 take both.
- i. Draw a Venn diagram. (4 marks)
 - ii. Find number of students who take only Programming. (2 marks)
 - iii. Find number of students who take only Networking. (2 marks)
 - iv. Find number who take either Programming or Networking but not both. (3 marks)
- b. Using 2's complement arithmetic, perform the following binary operations:
- i. $100110_2 - 11010_2$ (4 marks)
 - ii. $62_{16} - 24_8$ (5 marks)