AFRICA UNIVERSITY
A United Methodist-Related Institution

"Investing in Africa's Future"

COLLEGE OF ENGINEERING AND APPLIED SCIENCES

AIN 1104: OPTIMISATION TECHNIQUES

END OF FIRST SEMESTER EXAMINATIONS

NOVEMBER 2025

LECTURER: MR. E. CHIKAKA

DURATION: 3 HOURS

INSTRUCTIONS

ANSWER **ALL** QUESTIONS FROM SECTION A AND **ANY THREE (3)** FROM SECTION B

THE MARK ALLOCATION FOR EACH QUESTION IS INDICATED AT THE END OF THE QUESTION

CREDIT WILL BE GIVEN FOR LOGICAL, SYSTEMATIC, AND NEAT PRESENTATION

Section A (40 Marks) – Short Answer Questions (Answer ALL)

Question 1.

Define optimisation in the context of computer science. Give two real-world examples where optimisation techniques are applied. [5]

Question 2.

Formulate the following as a Linear Programming (LP) model:
A factory produces tables and chairs. Each table requires 4 hours of labor and 2 units of wood. Each chair requires 3 hours of labor and 1 unit of wood. The factory has at most 240 hours of labor and 100 units of wood. Profit per table = $60, profit per chair = $40. [5]

Question 3.

State two differences between the **Graphical Method** and the **Simplex Algorithm** in solving LP problems. [5]

Question 4.

Explain the concept of **duality** in Linear Programming. Why is sensitivity analysis important? [5]

Question 5.

A company needs to transport goods from 3 warehouses to 4 stores at minimum cost. Identify the type of optimisation problem this represents and name two algorithms used to solve it. [5]

Question 6.

Differentiate between **Integer Programming** and **Linear Programming**. Give one application where Integer Programming is more suitable. [5]

Question 7.

Outline the main steps of **Dijkstra's algorithm** in network optimisation. [5]

Question 8.

Compare metaheuristics such as **Genetic Algorithms (GA)** with exact optimisation methods. Mention one advantage and one limitation of GAs. [5]

Section B (60 Marks) – Structured Questions (Answer ANY THREE)

Question 9.

Linear Programming – Graphical & Simplex
A company makes two products, A and B.

Profit: $5 per unit of A, $3 per unit of B.

Each unit of A requires 1 machine hour and 2 labor hours.

Each unit of B requires 1 machine hour and 1 labor hour.

Available: 6 machine hours and 8 labor hours.

(a) Formulate this as an LP model.
(b) Solve graphically.
(c) Show how the same problem can be solved using the simplex method (first iteration only).
[*20*]

Question 10.

Duality & Sensitivity Analysis
(a) Define the dual of a Linear Programming problem.
(b) Derive the dual for the following primal problem:

Maximize: $Z=3x_1+2x_2$
Subject to: $x_1 + 2x_2 \leq 8$, $3x_1 + 2x_2 \leq 12$, $x_1, x_2 \geq 0$

(c) Explain the economic meaning of **shadow prices** in this context.
[20]

Question 11.

Transportation & Assignment Problems
The transportation costs from three plants (P1, P2, P3) to three warehouses (W1, W2, W3) are given below. Supply and demand are also provided:

	W1	W2	W3	Supply
P1	2	3	1	30
P2	5	4	8	50
P3	5	6	8	20
Demand	20	40	40	

(a) Formulate this as a transportation problem.
(b) Use the **North-West Corner Method** to obtain an initial feasible solution.
(c) Apply the **MODI method** to test for optimality (outline steps, full working not required).

[*20*]

Question 12.

Dynamic Programming & Nonlinear Programming
(a) A resource allocation problem requires dividing 4 identical units of resource among 2 activities to maximize profit. Profits are given:

Activity A: f(0)=0, f(1)=2, f(2)=4, f(3)=7, f(4)=9

Activity B: g(0)=0, g(1)=3, g(2)=5, g(3)=6, g(4)=7

Use **Dynamic Programming** to determine the optimal allocation.
(b) Solve the following constrained optimisation problem using calculus:

Maximize f(x,y)=xy
Subject to: $x^2+y^2=25$

[*20*]

Question 13.

Metaheuristics & Network Optimisation
(a) Explain how a **Genetic Algorithm (GA)** can be applied to solve the **Traveling Salesman Problem (TSP)**. Illustrate with the steps: selection, crossover, and mutation.
(b) Apply **Kruskal's algorithm** to find the **Minimum Spanning Tree (MST)** of the following graph:

Vertices = {A, B, C, D, E}
Edges with weights: A–B(2), A–C(3), B–C(1), B–D(4), C–D(5), C–E(6), D–E(7)

Show all steps.

[20]

END OF EXAMINATION