



NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
FACULTY OF APPLIED SCIENCE
DEPARTMENT OF COMPUTER SCIENCE
DATA STRUCTURES AND ALGORITHMS
SCS 1217

Examination Paper
March 2025

This examination paper consists of five (5) pages

Time Allowed : 3 hours
Total Marks : 100
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INSTRUCTIONS

1. Answer **any** four (4) questions
2. Use C, Python or Java to write program codes
3. The use of Scientific Calculators is permitted.

MARK ALLOCATION

QUESTION	MARKS
1	25
2	25
3	25
4	25
5	25
TOTAL	100

Question One

- a) Define the following terms as they are used in Data Structures and Algorithms
- i. Spanning Tree [2]
 - ii. Hash Table [2]
 - iii. Binary Search Tree [2]
- b) Consider the following expression: $(2 + 4) * (4 + 16 / 8)$
- i. Convert the infix expression to postfix [2]
 - ii. Illustrate how you would evaluate the postfix expression obtained in b (i) above using a stack [5]
- c) As a network administrator for a large university, you are tasked with managing the institution's data traffic across its network infrastructure. The network consists of various nodes (such as switches, and routers) interconnected by links (such as ethernet and fibre optic cables). The goal is to ensure efficient data transmission by finding optimal paths for data packets while minimising latency and avoiding congestion.
- i. Identify the most suitable data structure that can be used to manage the network routing problem. Give a justification for your answer [3]
 - ii. Identify the most suitable algorithm that can be used to solve the network routing problem. Give a justification for your answer [3]
- d) Write a pseudocode for an algorithm to insert a node at the beginning of a linked list. [6]

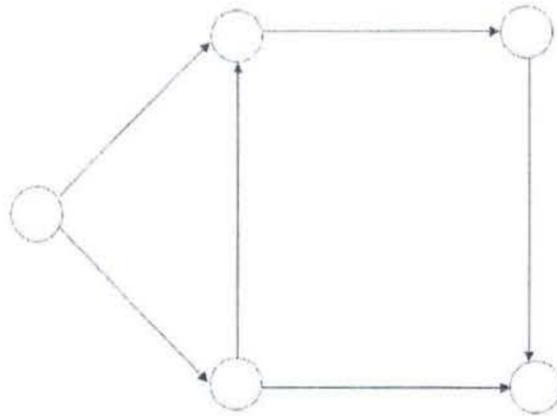
Question Two

- a) With the aid of a diagram, explain the following terms as they are used in Graphs
- i. Breadth First Search [3]
 - ii. Depth First Search [3]
- b) Illustrate how Bellman Ford's algorithm can be used to find the single source shortest path. Use the graph defined below to illustrate your answer:

Vertices: S, A, B, C, D

Source S [10]

Edges	A → C	B → A	B → D	C → D	S → A	S → B
Cost	3	-5	1	2	4	6



Hint for Question 2(b)

- c) Write a function that reverses an array of integers using the stack data structure.
 Input : An integer array of size n
 Output : The function should reverse the array and print the reversed array [9]

Question Three

- a) Explain the following algorithm design strategies
- i. Branch and Bound [2]
 - ii. Backtracking [2]
 - iii. Brute force [2]
- b) Explain how the bucket sort algorithm works using the following list of floating point numbers and 5 buckets based on the range of the values below:

In your explanation, include details on how you would create buckets, distribute the elements, sort each bucket, and concatenate the final sorted list. [10]

List for Question 3(b)

0.42	0.32	0.24	0.12	0.34	0.9	0.76	0.88	0.05	0.64
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- c) Write program code to implement the Enqueue operation using an array. The Enqueue operation adds an element to the rear of the queue, following the First in, First out (FIFO) principle. Your goal is to implement this operation and handle the following:
- Enqueue operation: add an element to the rear of the queue
 - Ensure that the queue overflow (when trying to Enqueue into a full queue) is properly handled
 - Your implementation should consider a fixed size queue (i.e., the size of the array is predetermined). [9]

Question Four

a) Differentiate between a circular queue and a priority queue based on the following criteria: definition, order of removal, and insertion position. [4]

b) Consider the following knapsack problem:

Number of items = 7

Knapsack's maximum carrying capacity = 15

Table 1 – Knapsack Problem

Objects	1	2	3	4	5	5	7
Profit	10	5	15	7	6	18	3
Weight	2	3	5	7	1	4	1

- i. Explain one real life application of the Knapsack Algorithm [2]
- ii. Show the step-by-step procedure to determine the optimal solution for a Fractional Knapsack problem using a Greedy algorithm. [6]
- iii. Show the step-by-step procedure to determine the optimal solution for a 0/1 Knapsack Problem using a Greedy algorithm [6]

c) Write a function to implement a binary search algorithm that finds an element in an array. The function should take three inputs:

- arr[] : an array of integers
- n : the size of the array
- target : the element to search for

The function should return the index of the "target" element in the array arr[] if it exists, or "-1" if it does not exist [7]

Question Five

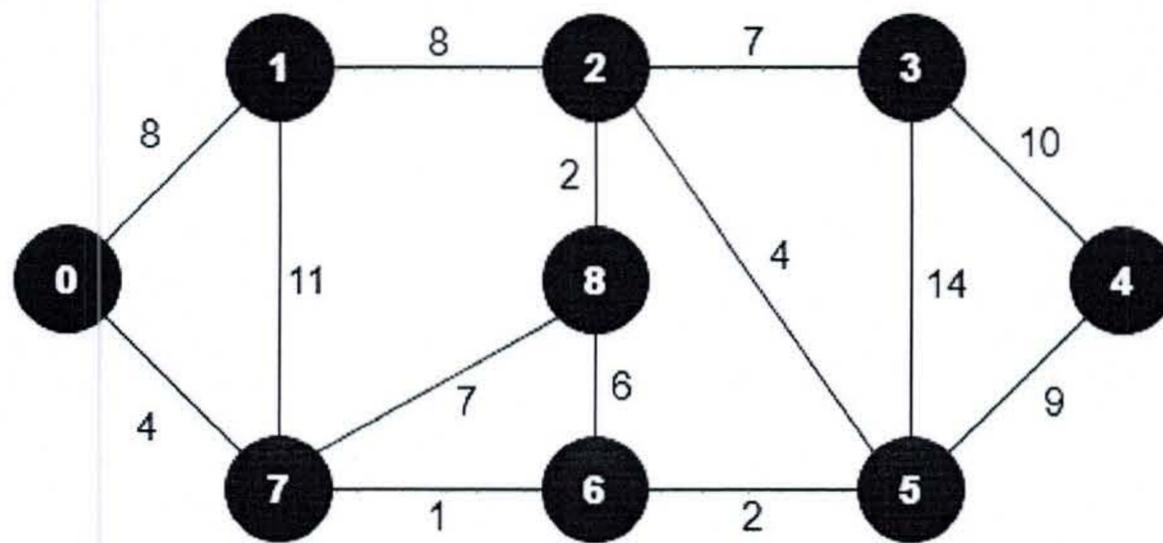
a) Define P and NP problems, and provide an example for each [6]

b) Given the following post order and inorder traversals, construct the binary tree.

Post order : [4, 7, 5, 2, 8, 6, 3, 1]

In order : [4, 2, 7, 5, 1, 8, 6, 3] [5]

c) Explain how a Minimum Spanning Tree (MST) is constructed from the graph below, using Kruskal's algorithm. In your answer, show the step-by-step procedures, construct the Minimum Spanning Tree, compute its weight and describe one application of Kruskal's algorithm. [8]



Graph for Question 5(c)

- d) Consider a Salesperson who needs to visit 4 cities: A, B, C, and D. The salesperson starts at city A and must visit each city exactly once before returning to city A. The distance in kilometres between the cities is as follows:

Table 2 - Distance between Cities in Kilometres

	A	B	C	D
A	0	1 400	980	1 330
B	1 400	0	2 150	2 200
C	980	2 150	0	350
D	1 330	2 200	350	0

Use the Travelling Salesperson's Algorithm to find the shortest possible tour that the salesperson can take to visit all 4 cities exactly once and return to city A. [6]