

The
Management
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UNDERGRADUATE UNIVERSITY EXAMINATIONS
SCHOOL OF SCIENCE AND TECHNOLOGY
DEGREE OF BACHELOR OF BUSINESS INFORMATION
TECHNOLOGY

**BBIT 305/ BBIT 310 : DATA STRUCTURES AND ALGORITHMS
(DSA)**

DATE: 28TH JULY 2026

DURATION: 2 HOURS

MAXIMUM MARKS: 70

INSTRUCTIONS:

1. Write your registration number on the answer booklet.
2. **DO NOT** write on this question paper.
3. This paper contains **SIX (6)** questions.
4. Question **ONE** is compulsory.
5. Answer any other **THREE** questions.
6. Question **ONE** carries **25 MARKS** and the rest carry **15 MARKS** each.
7. **Write all your answers in the Examination answer booklet provided.**

QUESTION ONE

Read the scenario below carefully and answer ALL parts (a - d).

CASE STUDY: MamaFresh Online Grocery Platform

MamaFresh is a Nairobi-based startup that delivers fresh groceries to customers across the city. Their new software system must handle the following daily operations:

1. A customer places an order; the system must find the customer record instantly by their phone number from a database of 50,000 registered customers.
2. Orders are processed in the exact sequence they arrive — no order should jump the queue.
3. The delivery route planner maps road connections between 12 Nairobi neighbourhoods to find the fastest path for a rider.
4. A product catalogue of 3,000 items must be searched quickly by product code. The catalogue is rebuilt and re-sorted every morning.
5. When a rider's device goes offline mid-delivery, the last 5 GPS coordinates are stored temporarily so the route can be retraced in reverse order on reconnection.

The lead developer, Amina, has proposed using a single Array for ALL five operations above.

a) For each of the five operations described in the MamaFresh scenario, name the most appropriate data structure Amina should use. Present your answers in the table below.

(5 marks)

Operation	Most Appropriate Data Structure (Student to fill in)
(i) Instant customer lookup by phone number	
(ii) Processing orders in arrival sequence	
(iii) Mapping road connections between neighbourhoods	
(iv) Sorted product catalogue searched by product code	
(v) Storing last 5 GPS coordinates for reverse retrieval	

(1 mark

each)

b) Explain and Describe

(i) Amina proposes using an Array for ALL five operations. Explain why an Array is unsuitable for Operation (i) — instant customer lookup. In your answer, describe how Array search works and state its time complexity.

(3 Marks)

(ii) Explain what FIFO means and describe how a Queue enforces this property. Use the word 'front' and 'rear' in your answer.

(2 Marks)

(iii) Describe what a Stack is and explain why it is the correct structure for Operation (v) — storing GPS coordinates for reverse retrieval. State the time complexity of the Push and Pop operations.

(3 Marks)

c) Apply and Trace

The MamaFresh order queue currently holds the following orders (front → rear): Order1, Order2, Order3.

A new batch of operations arrives: ENQUEUE(Order4), ENQUEUE(Order5), DEQUEUE, DEQUEUE, ENQUEUE(Order6), DEQUEUE.

(i) Trace each operation step by step. Show the queue state (front → rear) after every single operation.

(4 Marks)

(ii) After all operations, which order is currently at the front of the queue? **(1 Mark)**

(iii) A rider's device captured GPS points in this order: A, B, C, D, E (A was captured first). Show the Stack state after each PUSH. Then show the values returned by three consecutive POP operations.

(3 Marks)

d) Algorithm Properties

(i) The MamaFresh product catalogue is searched using Binary Search. State TWO conditions that must be true about the catalogue BEFORE Binary Search can be applied.

(2 Marks)

(ii) State the time complexity of Binary Search in the Best Case and Worst Case. For a catalogue of 3,000 items, calculate the maximum number of comparisons Binary Search would ever need.

(2 Marks)

QUESTION TWO— Sorting & Searching Algorithms

a) Sorting Algorithm Properties

- (i) Name the sorting algorithm that works by repeatedly finding the MINIMUM element from the unsorted portion and placing it at the beginning. **(1 Mark)**
- (ii) Which sorting algorithm is described as ‘like sorting playing cards in your hand, picking one card at a time and inserting it in the correct position’? **(1 Mark)**
- (iii) Complete the table below with the correct Big-O values for each sorting algorithm:
(3 Marks)

Algorithm	Best Case	Average Case	Worst Case	Space	Stable?
Selection Sort					
Insertion Sort					
Merge Sort					
Quick Sort					

b) Explain Sorting Mechanics

- (i) Explain in your own words how Merge Sort divides and conquers a list. Why does it guarantee $O(n \log n)$ in ALL cases, unlike Quick Sort? **(3 Marks)**
- (ii) Explain what is meant by a ‘stable’ sorting algorithm. Why would stability matter when sorting a list of students first by class, then by name? **(2 Marks)**

c) Trace Sorting Algorithms

Given the array: [64, 25, 12, 22, 11]

- (i) Perform a complete step-by-step trace of SELECTION SORT on this array. Show the array state after each pass. **(3 Marks)**
- (ii) Apply BINARY SEARCH to find the value 22 in the sorted result from (i). Show the low, mid, and high values at each step. **(2 Marks)**

QUESTION THREE— Linked Lists, Stacks & Queues

a) Definitions & Operations

(i) State the difference between a STACK and a QUEUE. Name the primary operations for each. **(2 Marks)**

(ii) Name THREE real-world applications of a Stack and TWO real-world applications of a Queue. **(2 Marks)**

b) Explain Linked List Behaviour

(i) Explain why a Linked List is preferred over an Array when frequent INSERTIONS and DELETIONS are required in the middle of the list. Use Big-O notation in your explanation. **(3 Marks)**

(ii) Describe what a SET is and explain why a Set is faster than a List for membership testing. Name the internal mechanism that gives a Set its speed.

(2 Marks)

c) Stack and Queue Traces

(i) Trace the following Stack operations and state the final stack contents (top to bottom):

(3 Marks)

PUSH(10), PUSH(20), PUSH(30), POP(), PUSH(40), POP(), PUSH(50), POP(), POP()

(ii) A Queue contains: 5, 10, 15, 20 (front → rear). Apply: DEQUEUE, DEQUEUE, ENQUEUE(25), ENQUEUE(30), DEQUEUE. Show the queue state after each operation and state the FINAL contents.

(3 Marks)

QUESTION FOUR— Trees, BST & Hash Tables

a) BST and Hash Table Definitions

(i) State the BST ordering property that distinguishes it from a general binary tree.

(1 Mark)

(ii) Name the THREE traversal methods for a binary tree and state the order in which each visits nodes (Left, Root, Right).

(2 Marks)

(iii) What is a collision in a hash table? Name ONE collision resolution strategy.

(1 Mark)

b) BST Properties & Hash Tables

(i) Explain why INORDER traversal of a BST always produces elements in sorted ascending order.

(2 Marks)

(ii) A hash table has 7 buckets and uses: $\text{hash}(\text{key}) = \text{key} \bmod 7$. Explain step by step what happens when you insert keys 14 and 21, and how CHAINING resolves the resulting collision.

(3 Marks)

c) Build and Traverse a BST

Insert the following values into an initially empty BST in the given order: 45, 20, 65, 10, 35, 55, 80.

(i) Draw the BST structure (use indented text or a diagram).

(2

Marks)

(ii) Write out the INORDER and PREORDER traversal sequences for your tree.

**(2
Marks)**

(iii) Starting from the root, trace the search for value 35. State the comparison made at each node and how many steps are needed.

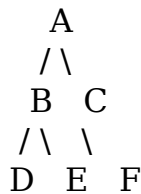
(2 Marks)

QUESTION FIVE— Trees, Graphs & Traversal

a) Tree and Graph Terminology

(i) Using the tree below, identify: the root node, all leaf nodes, the height of the tree, and the depth of node E.

(2 Marks)



(ii) State ONE key difference between a DIRECTED graph and an UNDIRECTED graph. Give a real-world example of each.

(2 Marks)

b) DFS vs BFS

(i) Explain the difference between Depth-First Search (DFS) and Breadth-First Search (BFS). State the internal data structure each uses and explain why that data structure suits the traversal style.

(3 Marks)

(ii) Explain why BFS guarantees the SHORTEST path in an unweighted graph but DFS does not.

(2 Marks)

c) Graph Traversal Traces

Graph edges (undirected): Gate-Library, Gate-Admin, Library-Lab, Admin-Canteen, Lab-Canteen, Lab-Hostel

(i) Represent this graph as an Adjacency List. **(2 Marks)**

(ii) Trace BFS starting from Gate (visit neighbours alphabetically). Show the queue contents after each step.

(2 Marks)

(iii) Trace DFS starting from Gate (visit neighbours alphabetically). Show which nodes are visited in order. **(2 Marks)**

QUESTION SIX

a) Multiple Choice Questions

1. What is the time complexity of accessing an element in an array by its index?

- A) $O(n)$
- B) $O(\log n)$
- C) $O(1)$
- D) $O(n^2)$

(2 Marks)

2. Which of the following sorting algorithms has a GUARANTEED worst-case time complexity of $O(n \log n)$?

- A) Quick Sort
- B) Selection Sort
- C) Merge Sort
- D) Insertion Sort

(2

Marks)

3. When would you prefer a LINKED LIST over an ARRAY?

- A) When you need $O(1)$ random access by index
- B) When the maximum size is known at compile time
- C) When frequent insertions and deletions occur in the middle of the list
- D) When binary search will be used frequently

(2 Marks)

b) True / False Questions

1. True or False: Binary Search can be applied to an UNSORTED array and will still produce correct results.

(1 Mark)

2. True or False: A tree is a special type of graph that contains no cycles and has exactly one path between any two nodes.

(1 Mark)

3. True or False: Merge Sort is an in-place sorting algorithm that requires only $O(1)$ extra memory.

(1 Mark)

4. True or False: In a Queue, elements are removed from the SAME end they were inserted.

(1 Mark)

c) Short Answer Application

(i) Given sets $A = \{3, 6, 9, 12, 15\}$ and $B = \{6, 12, 18, 24\}$, compute: $A \cup B$, $A \cap B$, and $A - B$.

(2 Marks)

(ii) A sorted array contains: $[5, 11, 17, 23, 29, 35, 41]$. Apply Binary Search to find the value 29. Show the low, mid, and high pointer values at each step. **(3 Marks)**