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## TASK 1

```

class Stack:
    """
    Stack Data Structure implementation using Python list.
    Follows LIFO (Last In First Out) principle.
    """

    def __init__(self):
        """
        Initializes an empty stack.
        """
        self.items = []

    def push(self, item):
        """
        Adds an element to the top of the stack.

        Parameters:
        item (any): Element to be pushed onto the stack
        """
        self.items.append(item)

    def pop(self):
        """
        Removes and returns the top element from the stack.

        Returns:
        any: Top element of the stack
        If stack is empty, returns None
        """
        if not self.is_empty():
            return self.items.pop()
        return None

    def peek(self):
        """
        Returns the top element of the stack without removing it.

        Returns:
        any: Top element of the stack
        If stack is empty, returns None
        """
        if not self.is_empty():
            return self.items[-1]
        return None

    def is_empty(self):
        """
        Checks whether the stack is empty.

        Returns:
        bool: True if stack is empty, False otherwise
        """
        return len(self.items) == 0

# Sample usage
s = Stack()
s.push(10)
s.push(20)
print("Top element:", s.peek())
print("Popped element:", s.pop())
print("Is stack empty?", s.is_empty())

```

```

Top element: 20
Popped element: 20
Is stack empty? False

```

## TASK 2

```

class Queue:
    """
    Queue Data Structure implementation using Python list.
    Follows FIFO (First In First Out) principle.
    """

    def __init__(self):
        """
        Initializes an empty queue.
        """
        self.items = []

    def enqueue(self, item):
        """
        Adds an element to the rear of the queue.

        Parameters:
        item (any): Element to be added to the queue
        """
        self.items.append(item)

    def dequeue(self):
        """
        Removes and returns the front element of the queue.

        Returns:
        any: Front element of the queue
        If queue is empty, returns None
        """
        if not self.is_empty():
            return self.items.pop(0)
        return None

    def peek(self):
        """
        Returns the front element without removing it.

        Returns:
        any: Front element of the queue
        If queue is empty, returns None
        """
        if not self.is_empty():
            return self.items[0]
        return None

    def size(self):
        """
        Returns the number of elements in the queue.

        Returns:
        int: Size of the queue
        """
        return len(self.items)

    def is_empty(self):
        """
        Checks whether the queue is empty.

        Returns:
        bool: True if queue is empty, False otherwise
        """
        return len(self.items) == 0

# Sample usage
q = Queue()
q.enqueue(10)
q.enqueue(20)
q.enqueue(30)

print("Front element:", q.peek())
print("Dequeued element:", q.dequeue())

```

```
print("Queue size:", q.size())
```

```
Front element: 10
Dequeued element: 10
Queue size: 2
```

## TASK 3

```
class Node:
    """
    Node class represents a single element in a singly linked list.
    """

    def __init__(self, data):
        """
        Initializes a node with data and a reference to the next node.

        Parameters:
        data (any): Value stored in the node
        """
        self.data = data
        self.next = None

class LinkedList:
    """
    Singly Linked List implementation.
    """

    def __init__(self):
        """
        Initializes an empty linked list.
        """
        self.head = None

    def insert(self, data):
        """
        Inserts a new node at the beginning of the linked list.

        Parameters:
        data (any): Value to be inserted
        """
        new_node = Node(data)
        new_node.next = self.head
        self.head = new_node

    def display(self):
        """
        Displays all elements of the linked list.
        """
        temp = self.head
        while temp:
            print(temp.data, end=" -> ")
            temp = temp.next
        print("None")

# Sample usage
ll = LinkedList()
ll.insert(10)
ll.insert(20)
ll.insert(30)

ll.display()
```

```
30 -> 20 -> 10 -> None
```

## TASK 4

```
class Node:
    """
    Node class represents a single node in a Binary Search Tree.
    """
```

```

def __init__(self, key):
    """
    Initializes a node with a key value.

    Parameters:
    key (int): Value stored in the node
    """
    self.key = key
    self.left = None
    self.right = None

class BST:
    """
    Binary Search Tree implementation with recursive insert
    and in-order traversal methods.
    """

    def __init__(self):
        """
        Initializes an empty BST.
        """
        self.root = None

    def insert(self, key):
        """
        Inserts a key into the BST.

        Parameters:
        key (int): Value to be inserted
        """
        self.root = self._insert_recursive(self.root, key)

    def _insert_recursive(self, node, key):
        """
        Recursively inserts a key into the BST.

        Parameters:
        node (Node): Current node
        key (int): Value to be inserted

        Returns:
        Node: Updated node
        """
        if node is None:
            return Node(key)

        if key < node.key:
            node.left = self._insert_recursive(node.left, key)
        elif key > node.key:
            node.right = self._insert_recursive(node.right, key)

        return node

    def inorder(self):
        """
        Performs in-order traversal of the BST.
        """
        self._inorder_recursive(self.root)

    def _inorder_recursive(self, node):
        """
        Recursive helper for in-order traversal.

        Parameters:
        node (Node): Current node
        """
        if node:
            self._inorder_recursive(node.left)
            print(node.key, end=" ")
            self._inorder_recursive(node.right)

# Sample usage
bst = BST()
bst.insert(50)

```

```

bst.insert(30)
bst.insert(70)
bst.insert(20)
bst.insert(40)
bst.insert(60)
bst.insert(80)

print("In-order Traversal:")
bst.inorder()

```

```

In-order Traversal:
20 30 40 50 60 70 80

```

## TASK 5

```

class HashTable:
    """
    Hash Table implementation using chaining for collision handling.
    """

    def __init__(self, size=10):
        """
        Initializes the hash table with a fixed size.

        Parameters:
        size (int): Number of buckets in the hash table
        """
        self.size = size
        self.table = [[] for _ in range(size)]

    def _hash(self, key):
        """
        Generates a hash index for a given key.

        Parameters:
        key (str): Key to be hashed

        Returns:
        int: Hash index
        """
        return hash(key) % self.size

    def insert(self, key, value):
        """
        Inserts a key-value pair into the hash table.

        Parameters:
        key (str): Key to insert
        value (any): Value associated with the key
        """
        index = self._hash(key)

        # Check if key already exists and update
        for pair in self.table[index]:
            if pair[0] == key:
                pair[1] = value
                return

        # Otherwise, add new key-value pair
        self.table[index].append([key, value])

    def search(self, key):
        """
        Searches for a value by key in the hash table.

        Parameters:
        key (str): Key to search

        Returns:
        any: Value if found, otherwise None
        """
        index = self._hash(key)

        for pair in self.table[index]:
            if pair[0] == key:

```

```

        return pair[1]

    return None

def delete(self, key):
    """
    Deletes a key-value pair from the hash table.

    Parameters:
    key (str): Key to delete

    Returns:
    bool: True if deleted, False if key not found
    """
    index = self._hash(key)

    for i, pair in enumerate(self.table[index]):
        if pair[0] == key:
            del self.table[index][i]
            return True

    return False

# Sample usage
ht = HashTable()

ht.insert("name", "Harini")
ht.insert("age", 20)
ht.insert("course", "AI")

print("Search name:", ht.search("name"))
ht.delete("age")
print("Search age:", ht.search("age"))

```

```

Search name: Harini
Search age: None

```

## TASK 6

```

class Graph:
    """
    Graph implementation using an adjacency list.
    """

    def __init__(self):
        """
        Initializes an empty graph.
        """
        self.graph = {}

    def add_vertex(self, vertex):
        """
        Adds a vertex to the graph.

        Parameters:
        vertex (any): Vertex to be added
        """
        if vertex not in self.graph:
            self.graph[vertex] = []

    def add_edge(self, vertex1, vertex2):
        """
        Adds an edge between two vertices (undirected graph).

        Parameters:
        vertex1 (any): First vertex
        vertex2 (any): Second vertex
        """
        # Ensure both vertices exist
        if vertex1 not in self.graph:
            self.add_vertex(vertex1)
        if vertex2 not in self.graph:
            self.add_vertex(vertex2)

```

```

# Add connections
self.graph[vertex1].append(vertex2)
self.graph[vertex2].append(vertex1)

def display(self):
    """
    Displays the graph connections.
    """
    for vertex in self.graph:
        print(vertex, "->", self.graph[vertex])

# Sample usage
g = Graph()
g.add_vertex("A")
g.add_vertex("B")
g.add_vertex("C")

g.add_edge("A", "B")
g.add_edge("A", "C")
g.add_edge("B", "C")

g.display()

```

```

A -> ['B', 'C']
B -> ['A', 'C']
C -> ['A', 'B']

```

## TASK 7

```

import heapq

class PriorityQueue:
    """
    Priority Queue implementation using heapq (min-heap).
    Lower priority value means higher priority.
    """

    def __init__(self):
        """
        Initializes an empty priority queue.
        """
        self.queue = []

    def enqueue(self, item, priority):
        """
        Inserts an element into the priority queue with a given priority.

        Parameters:
        item (any): Data to be stored
        priority (int): Priority of the item (lower value = higher priority)
        """
        heapq.heappush(self.queue, (priority, item))

    def dequeue(self):
        """
        Removes and returns the element with the highest priority.

        Returns:
        any: Item with highest priority
        If queue is empty, returns None
        """
        if self.is_empty():
            return None
        return heapq.heappop(self.queue)[1]

    def display(self):
        """
        Displays the elements in the priority queue.
        """
        print("Priority Queue:", self.queue)

    def is_empty(self):
        """
        Checks whether the priority queue is empty.

```

```

    Returns:
    bool: True if empty, False otherwise
    """
    return len(self.queue) == 0

```

```

# Sample usage
pq = PriorityQueue()
pq.enqueue("Task A", 3)
pq.enqueue("Task B", 1)
pq.enqueue("Task C", 2)

pq.display()
print("Dequeued:", pq.dequeue())
pq.display()

```

```

Priority Queue: [(1, 'Task B'), (3, 'Task A'), (2, 'Task C')]
Dequeued: Task B
Priority Queue: [(2, 'Task C'), (3, 'Task A')]

```

## TASK 8

```

from collections import deque

class DequeDS:
    """
    Double-Ended Queue (Deque) implementation using collections.deque.
    Allows insertion and removal from both ends.
    """

    def __init__(self):
        """
        Initializes an empty deque.
        """
        self.deque = deque()

    def insert_front(self, item):
        """
        Inserts an element at the front of the deque.

        Parameters:
        item (any): Element to be inserted
        """
        self.deque.appendleft(item)

    def insert_rear(self, item):
        """
        Inserts an element at the rear of the deque.

        Parameters:
        item (any): Element to be inserted
        """
        self.deque.append(item)

    def remove_front(self):
        """
        Removes and returns the front element of the deque.

        Returns:
        any: Front element, or None if deque is empty
        """
        if self.is_empty():
            return None
        return self.deque.popleft()

    def remove_rear(self):
        """
        Removes and returns the rear element of the deque.

        Returns:
        any: Rear element, or None if deque is empty
        """
        if self.is_empty():
            return None

```



```

        return self.deque.pop()

    def is_empty(self):
        """
        Checks whether the deque is empty.

        Returns:
        bool: True if empty, False otherwise
        """
        return len(self.deque) == 0

    def display(self):
        """
        Displays the elements of the deque.
        """
        print("Deque contents:", list(self.deque))

# Sample usage
dq = DequeDS()
dq.insert_front(10)
dq.insert_rear(20)
dq.insert_front(5)
dq.display()

print("Removed front:", dq.remove_front())
print("Removed rear:", dq.remove_rear())
dq.display()

```

```

Deque contents: [5, 10, 20]
Removed front: 5
Removed rear: 20
Deque contents: [10]

```

## TASK 9

### 1. Student Attendance Tracking

Requirement:

Daily log of students entering and exiting

Maintain order of entry/exit

Fast insertion and removal at both ends

✓ Best Data Structure: Deque

Reason:

Entry → insert at rear

Exit → remove from front

Supports real-time tracking efficiently

Operations Complexity:

Insert / Remove →  $O(1)$

✦ Why AI chose Deque: Deque handles both ends efficiently, unlike lists which are slower for front removals.

### 2. Event Registration System

Requirement:

Register participants

Quick search, add, and remove

Avoid duplicates

✓ Best Data Structure: Hash Table (Dictionary / Set)

Reason:

Fast lookup by student ID

Efficient removal

Prevents duplicate registrations

Operations Complexity:

Insert / Search / Delete  $\rightarrow O(1)$  average

✦ Why AI chose Hash Table: Hash tables are ideal for membership checks and fast updates.

### 3. Library Book Borrowing

Requirement:

Track available books

Store due dates

Quick access by book ID

✅ Best Data Structure: Hash Table

Reason:

Book ID  $\rightarrow$  Key

Book details & due date  $\rightarrow$  Value

Instant lookup and update

Operations Complexity:

Insert / Search / Update  $\rightarrow O(1)$

✦ Why AI chose Hash Table: Perfect for key-value relationships like BookID  $\rightarrow$  DueDate.

### 4. Bus Scheduling System

Requirement:

Maintain bus routes

Store stop-to-stop connections

Support route traversal

✅ Best Data Structure: Graph (Adjacency List)

Reason:

Stops  $\rightarrow$  Vertices

Routes  $\rightarrow$  Edges

Efficient for route mapping and traversal

Operations Complexity:

Traversal  $\rightarrow O(V + E)$

✦ Why AI chose Graph: Graphs naturally represent transport networks and connections.

### 5. Cafeteria Order Queue

Requirement:

Serve students in the order they arrive

First-Come-First-Served

✅ Best Data Structure: Queue

Reason:

FIFO principle

Simple and efficient order handling

Operations Complexity:

Enqueue / Dequeue  $\rightarrow O(1)$

✦ Why AI chose Queue: Queues are designed exactly for service-based systems.

📊 Summary Table System Module Data Structure Justification Student Attendance Deque Fast insert/remove from both ends Event Registration Hash Table Fast search, add, remove Library Borrowing Hash Table Instant book lookup Bus Scheduling Graph Represents routes & connections Cafeteria Orders Queue FIFO service order

