AI ASSISTED CODING

LAB-11.2

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BATCH:03

TASK-01:

Use AI to generate a Stack class with push, pop, peek, and is_empty methods.
Sample Input Code:
class Stack:
pass

PROMPT:

Generate a python stack class using push ,pop, is empty.

CODE:

11.2.1.py × | 11.2.2.py | 11.2.3.py | 11.2.4.py | 11.2.5.py | 11.2.6.py | 11.2.7.py | 11.2.8.py | 11.2.9.py | 11.2.10.py

11.2.1.py > Stack > __init__

```python
from typing import Any, List

class Stack:
    """
    A simple implementation of a Stack data structure.
    """
    def __init__(self) -> None:
        """
        Initializes an empty stack.
        """
        self._items: List[Any] = []

    def is_empty(self) -> bool:
        """
        Checks if the stack is empty.

        Returns:
            bool: True if the stack is empty, False otherwise.
        """
        return not self._items

    def push(self, item: Any) -> None:
        """
        Adds an item to the top of the stack.

        Args:
            item (Any): The item to be added to the stack.
        """
        self._items.append(item)

    def pop(self) -> Any:
        """
        Removes and returns the item at the top of the stack.

        Raises:
            IndexError: If the stack is empty.

        Returns:
            Any: The item at the top of the stack.
        """
        if self.is_empty():
            raise IndexError("pop from an empty stack")
        return self._items.pop()

    def peek(self) -> Any:
        """
        Returns the item at the top of the stack without removing it.

```

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```python
        Raises:
            IndexError: If the stack is empty.

        Returns:
            Any: The item at the top of the stack.
        """
        if self.is_empty():
            raise IndexError("peek from an empty stack")
        return self._items[-1]

    def __str__(self) -> str:
        """
        Returns a string representation of the stack.
        """
        return str(self._items)

    def __len__(self) -> int:
        """
        Returns the number of items in the stack.
        """
        return len(self._items)

# --- Example Usage ---
if __name__ == "__main__":
    print("Creating a new stack...")
    s = Stack()

    print(f"Is the stack empty? {s.is_empty()}")  # Expected: True

    print("\nPushing items: 10, 20, 30")
    s.push(10)
    s.push(20)
    s.push(30)

    print(f"Current stack: {s}")
    print(f"Stack size: {len(s)}")
    print(f"Is the stack empty? {s.is_empty()}")  # Expected: False

    print(f"\nPeeking at the top item: {s.peek()}")  # Expected: 30
    print(f"Current stack after peek: {s}")

    print(f"\nPopping an item: {s.pop()}")  # Expected: 30
    print(f"Current stack after pop: {s}")

    print(f"Popping another item: {s.pop()}")  # Expected: 20
    print(f"Current stack: {s}")

    print("\nPopping the last item...")
    s.pop()
    print(f"Is the stack empty now? {s.is_empty()}")  # Expected: True
```

OUTPUT:

```
PS C:\Users\ramch\OneDrive\Desktop\ai> & C:/Users/ramch/AppData/Local/Programs/Python/Python312/python.exe c:/Users/ramch/OneDrive/Desktop/ai/11.2.1.py
Creating a new stack...
Is the stack empty? True

Pushing items: 10, 20, 30
Current stack: [10, 20, 30]
Stack size: 3
Is the stack empty? False

Peeking at the top item: 30
Current stack after peek: [10, 20, 30]

Popping an item: 30
Current stack after pop: [10, 20]
Popping another item: 20
Current stack: [10]

Popping the last item...
Is the stack empty now? True
PS C:\Users\ramch\OneDrive\Desktop\ai>
```

OBSERVATION:

The AI generated the code in an efficient way according to the prompt as it developed the stack class.

TASK-02:

Use AI to implement a Queue using Python lists.
Sample Input Code:
class Queue:
pass

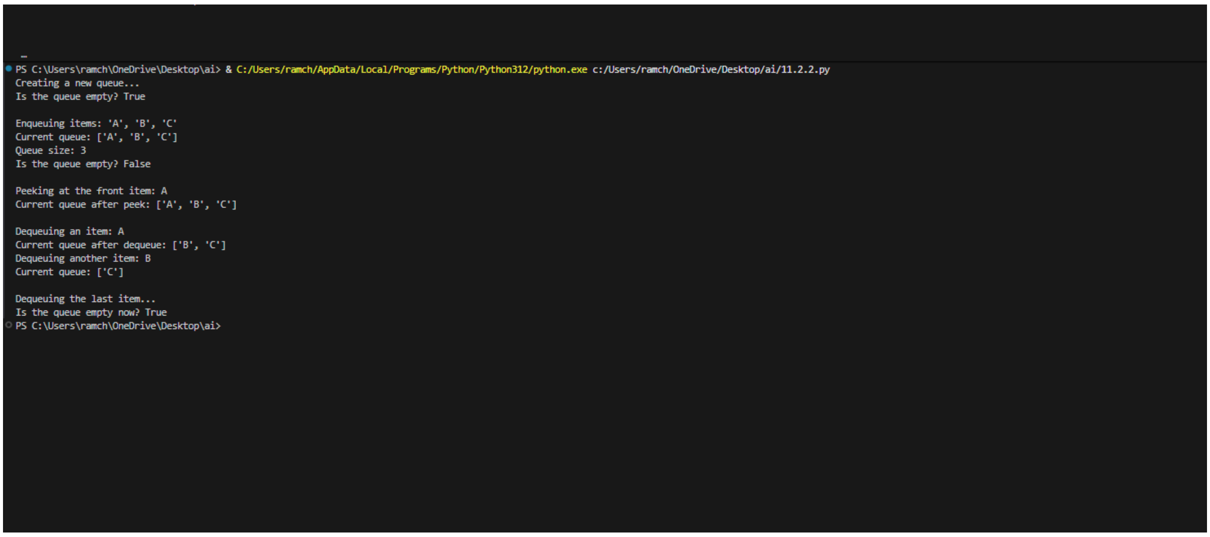
PROMPT:

Generate a python code to implement the queue in data structures

CODE:

```python
from typing import Any, List

class Queue:
    """
    A simple implementation of a Queue data structure using a Python list.
    Note: For performance-critical applications, collections.deque is preferred.
    """
    def __init__(self) -> None:
        """
        Initializes an empty queue.
        """
        self._items: List[Any] = []

    def is_empty(self) -> bool:
        """
        Checks if the queue is empty.

        Returns:
            bool: True if the queue is empty, False otherwise.
        """
        return not self._items

    def enqueue(self, item: Any) -> None:
        """
        Adds an item to the back (end) of the queue.

        Args:
            item (Any): The item to be added to the queue.
        """
        self._items.append(item)

    def dequeue(self) -> Any:
        """
        Removes and returns the item from the front of the queue.

        Raises:
            IndexError: If the queue is empty.

        Returns:
            Any: The item at the front of the queue.
        """
        if self.is_empty():
            raise IndexError("dequeue from an empty queue")
        return self._items.pop(0)

    def peek(self) -> Any:
        """
        Returns the item at the front of the queue without removing it.

        Raises:
            IndexError: If the queue is empty.

        Returns:
            Any: The item at the front of the queue.
        """
        if self.is_empty():
            raise IndexError("peek from an empty queue")
        return self._items[0]

    def __str__(self) -> str:
        """
        Returns a string representation of the queue.
        """
        return str(self._items)

    def __len__(self) -> int:
        """
        Returns the number of items in the queue.
        """
        return len(self._items)

# --- Example Usage ---
if __name__ == "__main__":
    print("Creating a new queue...")
    q = Queue()

    print(f"Is the queue empty? {q.is_empty()}")  # Expected: True

    print("\nEnqueuing items: 'A', 'B', 'C'")
    q.enqueue('A')
    q.enqueue('B')
    q.enqueue('C')

    print(f"Current queue: {q}")
    print(f"Queue size: {len(q)}")
    print(f"Is the queue empty? {q.is_empty()}")  # Expected: False

    print(f"\nPeeking at the front item: {q.peek()}")  # Expected: 'A'
    print(f"Current queue after peek: {q}")

    print(f"\nDequeuing an item: {q.dequeue()}")  # Expected: 'A'
    print(f"Current queue after dequeue: {q}")

    print(f"Dequeuing another item: {q.dequeue()}")  # Expected: 'B'
    print(f"Current queue: {q}")

    print("\nDequeuing the last item...")
    q.dequeue()
    print(f"Is the queue empty now? {q.is_empty()}")  # Expected: True
```

OUTPUT:



OBSERVATION:

The code generated by AI is more accurate about the queue in data structures and it also passed all the test cases.

TASK-03:

Use AI to generate a Singly Linked List with insert and display methods.

Sample Input Code:

class Node:

pass

class LinkedList:

pass

PROMPT:

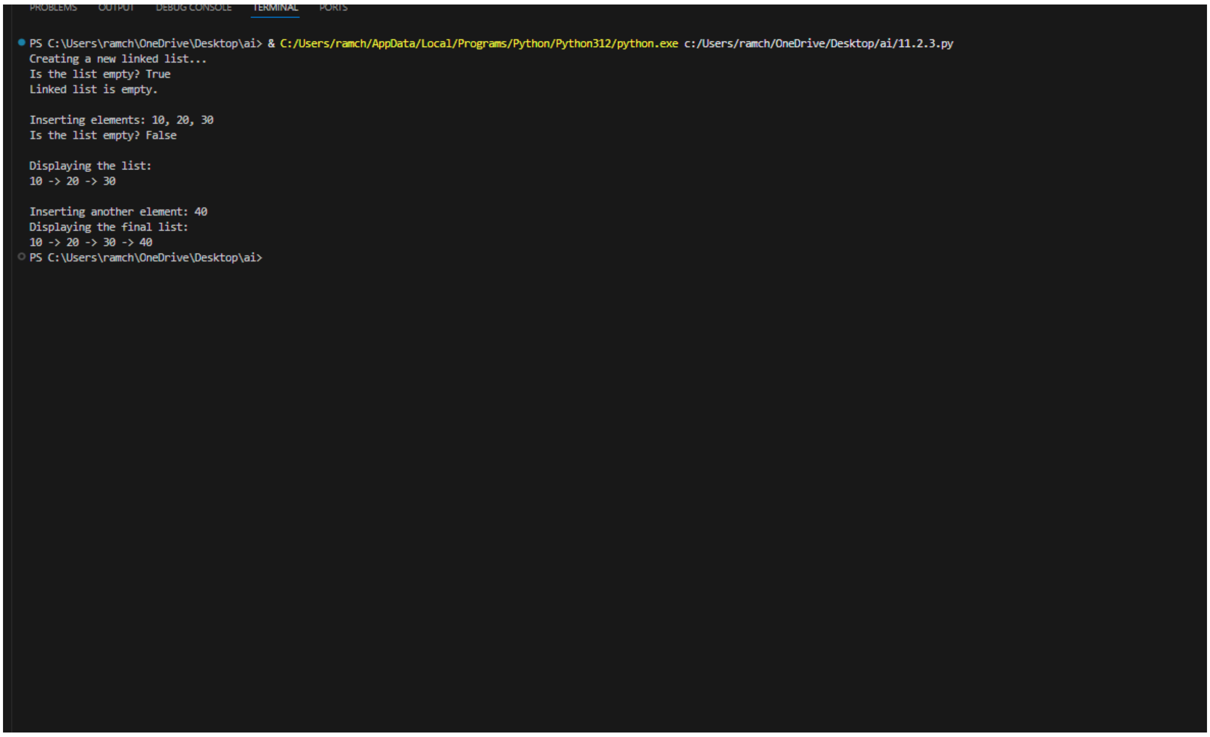
Generate a python code of singly linked list with insert and display methods.

CODE:

```python
from typing import Any, Optional

class Node:
    """
    An object for storing a single node of a linked list.
    Models two attributes: data and the link to the next node in the list.
    """
    def __init__(self, data: Any, next_node: Optional['Node'] = None):
        """
        Initializes a Node.

        Args:
            data (Any): The data to be stored in the node.
            next_node (Optional['Node']): The next node in the list. Defaults to None.
        """
        self.data = data
        self.next = next_node

class LinkedList:
    """
    A simple implementation of a Singly Linked List.
    """
    def __init__(self):
        """
        Initializes an empty linked list.
        """
        self.head: Optional[Node] = None

    def is_empty(self) -> bool:
        """
        Checks if the linked list is empty.

        Returns:
            bool: True if the list is empty, False otherwise.
        """
        return self.head is None

    def insert(self, data: Any) -> None:
        """
        Inserts a new node with the given data at the end of the list.

        Args:
            data (Any): The data for the new node.
        """
        new_node = Node(data)
        # If the list is empty, the new node becomes the head.
        if self.is_empty():
            self.head = new_node
            return

        # Otherwise, traverse to the end of the list.
        last_node = self.head
        while last_node.next:
            last_node = last_node.next

        # Set the next pointer of the last node to the new node.
        last_node.next = new_node
```

```python
class LinkedList:

    def display(self) -> None:
        """
        Traverses the linked list and prints the data of each node.
        """
        if self.is_empty():
            print("Linked list is empty.")
            return

        current = self.head
        nodes = []
        while current:
            nodes.append(str(current.data))
            current = current.next
        print(" -> ".join(nodes))

# --- Example Usage ---
if __name__ == "__main__":
    print("Creating a new linked list...")
    ll = LinkedList()

    print("Is the list empty?", ll.is_empty()) # Expected: True
    ll.display() # Expected: Linked list is empty.

    print("\nInserting elements: 10, 20, 30")
    ll.insert(10)
    ll.insert(20)
    ll.insert(30)

    print("Is the list empty?", ll.is_empty()) # Expected: False

    print("\nDisplaying the list:")
    ll.display() # Expected: 10 -> 20 -> 30

    print("\nInserting another element: 40")
    ll.insert(40)

    print("Displaying the final list:")
    ll.display() # Expected: 10 -> 20 -> 30 -> 40

```

OUTPUT:



OBSERVATION:

The code generated by the AI is used to perform the operations in the data structures like singly linked list performing insert and delete operations accurately.

TASK-04:

Use AI to create a BST with insert and in-order traversal methods.

Sample Input Code:

class BST:

pass

PROMPT:

Generate a python code which creates a BST with insert and in-order methods.

CODE:

11.2.4.py > Node > _init_

```python
from typing import Any, Optional, Generator
class Node:
    """
    An object for storing a single node of a Binary Search Tree.
    Models three attributes: the node's value, and pointers to the
    left and right children.
    """
    def __init__(self, value: Any):
        """
        Initializes a Node.
        Args:
            value (Any): The value to be stored in the node.
        """
        self.value = value
        self.left: Optional['Node'] = None
        self.right: Optional['Node'] = None
class BST:
    """
    A simple implementation of a Binary Search Tree (BST).
    """
    def __init__(self):
        """
        Initializes an empty BST.
        """
        self.root: Optional[Node] = None
    def insert(self, value: Any) -> None:
        """
        Inserts a new value into the BST, maintaining the BST property.

        Args:
            value (Any): The value to insert into the tree.
        """
        if self.root is None:
            self.root = Node(value)
        else:
            self._insert_recursive(self.root, value)
    def _insert_recursive(self, current_node: Node, value: Any) -> Node:
        """
        A private helper method to recursively find the correct position
        and insert the new node.

        Args:
            current_node (Node): The node to start the search from.
            value (Any): The value to insert.

        Returns:
            Node: The (potentially new) root of the subtree.
        """
        if value < current_node.value:
            if current_node.left is None:
                current_node.left = Node(value)
            else:
                self._insert_recursive(current_node.left, value)
        elif value > current_node.value:
            if current_node.right is None:
                current_node.right = Node(value)
            else:
                self._insert_recursive(current_node.right, value)
```

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11.2.4.py > Node > _init_

```python
class BST:
    def _insert_recursive(self, current_node: Node, value: Any) -> Node:
            # If value == current_node.value, we do nothing (no duplicates).
            return current_node

    def inorder_traversal(self) -> None:
        """
        Performs an in-order traversal of the tree and prints the values.
        In-order traversal visits nodes in ascending order.
        """
        print("In-order Traversal:", end=" ")
        nodes = list(self._inorder_generator(self.root))
        print(" -> ".join(map(str, nodes)))

    def _inorder_generator(self, current_node: Optional[Node]) -> Generator[Any, None, None]:
        """
        A private generator for recursively performing in-order traversal.
        It yields nodes in the order: left subtree, root, right subtree.

        Args:
            current_node (Optional[Node]): The node to start traversal from.
        """
        if current_node:
            yield from self._inorder_generator(current_node.left)
            yield current_node.value
            yield from self._inorder_generator(current_node.right)

# --- Example Usage ---
if __name__ == "__main__":
    print("Creating a new Binary Search Tree...")
    bst = BST()

    # The order of insertion matters for the tree's shape.
    print("Inserting values: 50, 30, 70, 20, 40, 60, 80")
    values_to_insert = [50, 30, 70, 20, 40, 60, 80]
    for val in values_to_insert:
        bst.insert(val)

    # The resulting tree structure will be:
    #       50
    #      /  \
    #    30    70
    #   / \   / \
    # 20  40 60  80

    # In-order traversal should print the nodes in sorted order.
    bst.inorder_traversal() # Expected: 20 -> 30 -> 40 -> 50 -> 60 -> 70 -> 80

    print("\nInserting a new value: 55")
    bst.insert(55)
    bst.inorder_traversal() # Expected: 20 -> 30 -> 40 -> 50 -> 55 -> 60 -> 70 -> 80

    print("\nAttempting to insert a duplicate value: 40")
    bst.insert(40) # This should not change the tree
    bst.inorder_traversal() # Expected: 20 -> 30 -> 40 -> 50 -> 55 -> 60 -> 70 -> 80
```

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OUTPUT:

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

```
PS C:\Users\ramch\OneDrive\Desktop\ai> & C:/Users/ramch/AppData/Local/Programs/Python/Python312/python.exe c:/Users/ramch/OneDrive/Desktop/ai/11.2.4.py
Creating a new Binary Search Tree...
Inserting values: 50, 30, 70, 20, 40, 60, 80
In-order Traversal: 20 -> 30 -> 40 -> 50 -> 60 -> 70 -> 80

Inserting a new value: 55
In-order Traversal: 20 -> 30 -> 40 -> 50 -> 55 -> 60 -> 70 -> 80

Attempting to insert a duplicate value: 40
In-order Traversal: 20 -> 30 -> 40 -> 50 -> 55 -> 60 -> 70 -> 80
PS C:\Users\ramch\OneDrive\Desktop\ai>
```

OBSERVATION:

The BST in data structures with insertion and in-order traversal methods are generated in python which are more helpful and in an efficient way to understand.

TASK-05:

Use AI to implement a hash table with basic insert, search, and delete

methods.
Sample Input Code:
class HashTable:
pass

PROMPT:

Generate a python code which helps to implement the hashtable with basic insert and delete methods.

CODE:

11.2.5.py > ...

```python
from typing import Any, List, Tuple, Optional

class HashTable:
    """
    A simple implementation of a Hash Table using chaining for collision resolution.
    """
    def __init__(self, size: int = 101):
        """
        Initializes the hash table.

        Args:
            size (int): The number of buckets in the hash table. A prime number
                        is often recommended to help distribute keys more uniformly.
        """
        if size < 1:
            raise ValueError("Hash table size must be a positive integer.")
        self.size = size
        # Initialize the table with empty lists (chains) for each bucket
        self.table: List[List[Tuple[Any, Any]]] = [[] for _ in range(self.size)]

    def _hash(self, key: Any) -> int:
        """
        A private method to compute the hash of a key and map it to a bucket index.
        This uses Python's built-in hash() and the modulo operator.

        Args:
            key (Any): The key to hash.

        Returns:
            int: The index of the bucket for the given key.
        """
        return hash(key) % self.size

    def insert(self, key: Any, value: Any) -> None:
        """
        Inserts a key-value pair into the hash table.
        If the key already exists, its value is updated.

        Args:
            key (Any): The key to insert.
            value (Any): The value associated with the key.
        """
        index = self._hash(key)
        bucket = self.table[index]

        # Check if the key already exists in the bucket (chain)
        for i, (existing_key, _) in enumerate(bucket):
            if existing_key == key:
                # Key found, update the value and return
                bucket[i] = (key, value)
                return

        # Key not found, append the new key-value pair to the chain
        bucket.append((key, value))

    def search(self, key: Any) -> Optional[Any]:
        """
        Searches for a key in the hash table and returns its value.
```

11.2.5.py > ...
class HashTable:
    def search(self, key: Any) -> Optional[Any]:

```python

        Args:
            key (Any): The key to search for.

        Returns:
            Optional[Any]: The value associated with the key if found, otherwise None.
        """
        index = self._hash(key)
        bucket = self.table[index]

        # Traverse the chain in the bucket
        for existing_key, value in bucket:
            if existing_key == key:
                return value  # Key found, return its value

        return None  # Key not found

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

        Args:
            key (Any): The key to delete.

        Returns:
            bool: True if the key was found and deleted, False otherwise.
        """
        index = self._hash(key)
        bucket = self.table[index]

        # Find the key in the chain and remove it
        for i, (existing_key, _) in enumerate(bucket):
            if existing_key == key:
                bucket.pop(i)
                return True  # Deletion successful

        return False  # Key was not found

    def __str__(self) -> str:
        """
        Returns a string representation of the hash table's contents.
        """
        elements = []
        for i, bucket in enumerate(self.table):
            if bucket:
                elements.append(f"Bucket {i}: {bucket}")
        return "\n".join(elements) if elements else "HashTable is empty."

# --- Example Usage ---
if __name__ == "__main__":
    print("Creating a new hash table of size 10...")
    ht = HashTable(10)

    print("\n--- Inserting Elements ---")
    ht.insert("name", "Alice")
    ht.insert("age", 30)
```

11.2.5.py > ...

```python

    print("\n--- Inserting Elements ---")
    ht.insert("name", "Alice")
    ht.insert("age", 30)
    ht.insert("city", "New York")
    ht.insert(99, "is a number") # Keys can be different types
    ht.insert("name", "Bob") # This will update the value for the key "name"

    print("Current Hash Table state:")
    print(ht)

    print("\n--- Searching for Elements ---")
    print(f"Search for 'name': {ht.search('name')}")         # Expected: Bob
    print(f"Search for 'age': {ht.search('age')}")          # Expected: 30
    print(f"Search for 'country': {ht.search('country')}")   # Expected: None

    print("\n--- Deleting Elements ---")
    print(f"Deleting 'age'... Success: {ht.delete('age')}")
    print(f"Deleting 'country'... Success: {ht.delete('country')}")

    print("\nFinal Hash Table state:")
    print(ht)

    print(f"\nSearching for 'age' again: {ht.search('age')}") # Expected: None
```

OUTPUT:

```
PS C:\Users\ramch\OneDrive\Desktop\ai> & C:/Users/ramch/AppData/Local/Programs/Python/Python312/python.exe c:/Users/ramch/OneDrive/Desktop/ai/11.2.5.py
Creating a new hash table of size 10...

--- Inserting Elements ---
Current Hash Table state:
Bucket 0: [('name', 'Bob')]
Bucket 1: [('age', 30), ('city', 'New York')]
Bucket 9: [(99, 'is a number')]

--- Searching for Elements ---
Search for 'name': Bob
Search for 'age': 30
Search for 'country': None

--- Deleting Elements ---
Deleting 'age'... Success: True
Deleting 'country'... Success: False

Final Hash Table state:
Bucket 0: [('name', 'Bob')]
Bucket 1: [('city', 'New York')]
Bucket 9: [(99, 'is a number')]

Searching for 'age' again: None
PS C:\Users\ramch\OneDrive\Desktop\ai>
```

OBSERVATION:

AI generated the code of data structures topic hashtable with basic insert, search and delete which aids us to understand the hashtable using the programming language like python.

TASK-06:

Use AI to implement a graph using an adjacency list.

Sample Input Code:

class Graph:

pass

PROMPT:

Generate a python code which implements the graph using an adjacency list in data structures.

CODE:

11.2.6.py > ...

```python
from typing import Any, Dict, List, Set

class Graph:
    """
    A simple implementation of an undirected graph using an adjacency list.
    """
    def __init__(self):
        """
        Initializes an empty graph.
        The adjacency list is represented as a dictionary where keys are
        vertices and values are lists of their adjacent vertices.
        """
        self.adj_list: Dict[Any, List[Any]] = {}

    def add_vertex(self, vertex: Any) -> bool:
        """
        Adds a vertex to the graph.

        Args:
            vertex (Any): The vertex to be added. Must be a hashable type.

        Returns:
            bool: True if the vertex was added, False if it already exists.
        """
        if vertex not in self.adj_list:
            self.adj_list[vertex] = []
            return True
        return False

    def add_edge(self, v1: Any, v2: Any) -> bool:
        """
        Adds an undirected edge between two vertices.
        If the vertices do not exist, they are created first.

        Args:
            v1 (Any): The first vertex.
            v2 (Any): The second vertex.

        Returns:
            bool: True if the edge was added, False if it already existed.
        """
        # Ensure both vertices exist in the graph
        self.add_vertex(v1)
        self.add_vertex(v2)

        # Add the edge for an undirected graph
        if v2 not in self.adj_list[v1]:
            self.adj_list[v1].append(v2)
            self.adj_list[v2].append(v1)
            return True
        return False

    def display(self) -> None:
        """
        Prints the adjacency list representation of the graph.
        """
        if not self.adj_list:
            print("Graph is empty.")
```

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11.2.1.py 11.2.2.py 11.2.3.py 11.2.4.py 11.2.5.py 11.2.6.py 11.2.7.py 11.2.8.py 11.2.9.py 11.2.10.py

11.2.6.py > ...

```python
class Graph:
    def display(self) -> None:
            print("Graph is empty.")
            return
        for vertex in self.adj_list:
            print(f"{vertex}: {self.adj_list[vertex]}")

    def get_vertices(self) -> List[Any]:
        """
        Returns a list of all vertices in the graph.
        """
        return list(self.adj_list.keys())

    def get_edges(self) -> List[tuple[Any, Any]]:
        """
        Returns a list of all edges in the graph.
        """
        edges = set()
        for vertex, neighbors in self.adj_list.items():
            for neighbor in neighbors:
                # To avoid duplicate edges like (A, B) and (B, A)
                if vertex < neighbor:
                    edges.add((vertex, neighbor))
        return list(edges)

# --- Example Usage ---
if __name__ == "__main__":
    print("Creating a new graph...")
    g = Graph()

    print("\n--- Adding Vertices ---")
    g.add_vertex("A")
    g.add_vertex("B")
    g.add_vertex("C")
    print("Graph after adding vertices:")
    g.display()

    print("\n--- Adding Edges ---")
    g.add_edge("A", "B")
    g.add_edge("B", "C")
    g.add_edge("C", "A")
    # Adding an edge with a new vertex
    g.add_edge("A", "D")
    print("Graph after adding edges:")
    g.display()

    print("\n--- Retrieving Vertices and Edges ---")
    print("Vertices:", g.get_vertices())
    print("Edges:", g.get_edges())

    print("\n--- Adding a duplicate edge (A, B) ---")
    success = g.add_edge("A", "B")
    print(f"Was the edge added? {success}") # Expected: False
    print("Graph state remains the same:")
    g.display()
```

OUTPUT:

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

```
PS C:\Users\ramch\OneDrive\Desktop\ai> & C:/Users/ramch/AppData/Local/Programs/Python/Python312/python.exe c:/Users/ramch/OneDrive/Desktop/ai/11.2.6.py
Creating a new graph...

--- Adding Vertices ---
Graph after adding vertices:
A: []
B: []
C: []

--- Adding Edges ---
Graph after adding edges:
A: ['B', 'C', 'D']
B: ['A', 'C']
C: ['B', 'A']
D: ['A']

--- Retrieving Vertices and Edges ---
Vertices: ['A', 'B', 'C', 'D']
Edges: [('A', 'C'), ('A', 'B'), ('B', 'C'), ('A', 'D')]

--- Adding a duplicate edge (A, B) ---
Was the edge added? False
Graph state remains the same:
A: ['B', 'C', 'D']
B: ['A', 'C']
C: ['B', 'A']
D: ['A']
PS C:\Users\ramch\OneDrive\Desktop\ai>
```

OBSERVATION:

Implementation of graph with the adjacency list is generated by the AI which makes us know about the graph in an efficient way and easy to understand.

TASK-07:

Use AI to implement a priority queue using Python’s heapq module.
Sample Input Code:
class PriorityQueue:
pass

PROMPT:

Write a python code which implement the priority queue using the heapq module.

CODE:

11.2.1.py 11.2.2.py 11.2.3.py 11.2.4.py 11.2.5.py 11.2.6.py 11.2.7.py 11.2.8.py 11.2.9.py 11.2.10.py

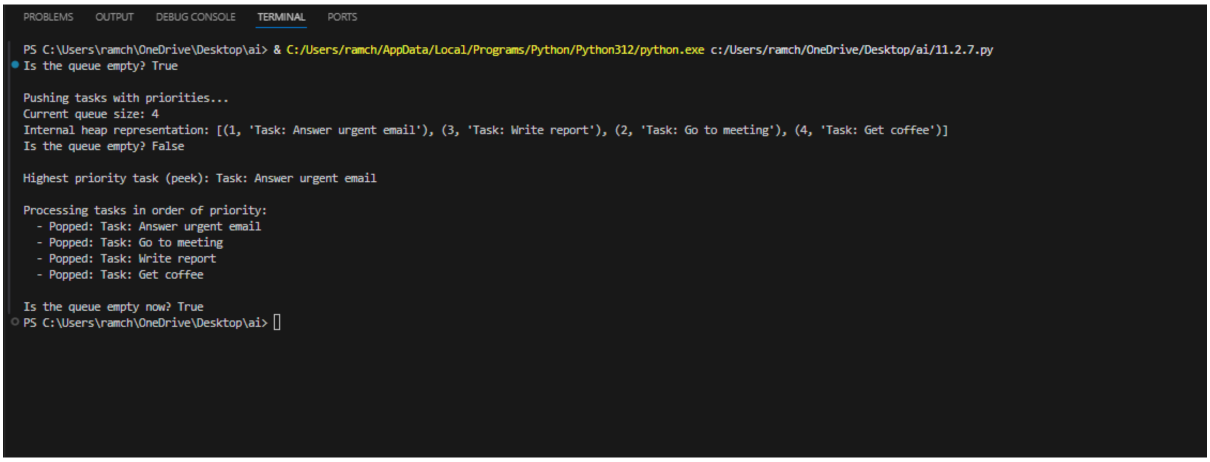
11.2.7.py > ...

```python
import heapq
from typing import Any, List, Tuple

class PriorityQueue:
    """
    A simple implementation of a Priority Queue using Python's heapq module.
    Lower numbers indicate higher priority.
    """
    def __init__(self):
        """
        Initializes an empty priority queue.
        """
        self._heap: List[Tuple[int, Any]] = []

    def push(self, item: Any, priority: int) -> None:
        """
        Adds an item to the queue with an associated priority.

        Args:
            item (Any): The item to be stored in the queue.
            priority (int): The priority of the item. Lower numbers are higher priority.
        """
        # heapq is a min-heap, so it naturally keeps the item with the
        # smallest priority value at the front.
        heapq.heappush(self._heap, (priority, item))

    def pop(self) -> Any:
        """
        Removes and returns the item with the highest priority (lowest number).

        Raises:
            IndexError: If the priority queue is empty.

        Returns:
            Any: The item with the highest priority.
        """
        if self.is_empty():
            raise IndexError("pop from an empty priority queue")
        # heappop removes and returns the smallest item from the heap.
        # We return only the item (index 1), not its priority (index 0).
        return heapq.heappop(self._heap)[1]

    def peek(self) -> Any:
        """
        Returns the item with the highest priority without removing it.

        Raises:
            IndexError: If the priority queue is empty.

        Returns:
            Any: The item with the highest priority.
        """
        if self.is_empty():
            raise IndexError("peek from an empty priority queue")
        # The highest priority item is always at the root of the heap (index 0).
        return self._heap[0][1]

    def is_empty(self) -> bool:
```

⚠ 0 Ln 104, Col 1

```python
class PriorityQueue:
    def is_empty(self) -> bool:
        Checks if the priority queue is empty.

        Returns:
            bool: True if the queue is empty, False otherwise.
        """
        return not self._heap

    def __len__(self) -> int:
        """
        Returns the number of items in the priority queue.
        """
        return len(self._heap)

    def __str__(self) -> str:
        """
        Returns a string representation of the priority queue's heap.
        Note: The list representation is not necessarily sorted.
        """
        return str(self._heap)

# --- Example Usage ---
if __name__ == "__main__":
    pq = PriorityQueue()
    print(f"Is the queue empty? {pq.is_empty()}") # Expected: True

    print("\nPushing tasks with priorities...")
    # (item, priority)
    pq.push("Task: Write report", 3)
    pq.push("Task: Answer urgent email", 1) # Highest priority
    pq.push("Task: Go to meeting", 2)
    pq.push("Task: Get coffee", 4) # Lowest priority

    print(f"Current queue size: {len(pq)}")
    print(f"Internal heap representation: {pq}")
    print(f"Is the queue empty? {pq.is_empty()}") # Expected: False

    print(f"\nHighest priority task (peek): {pq.peek()}") # Expected: Task: Answer urgent email

    print("\nProcessing tasks in order of priority:")
    while not pq.is_empty():
        task = pq.pop()
        print(f"  - Popped: {task}")

    print(f"\nIs the queue empty now? {pq.is_empty()}") # Expected: True
```

OUTPUT:



OBSERVATION:

The priority queue is generated using the heaqp module of python which implements them accurately.

TASK-08:

Use AI to implement a double-ended queue using collections.deque.

Sample Input Code:

class DequeDS:

pass

PROMPT:

Write a python code to implement the double-ended queue using collections .deque

CODE:

11.2.8.py > ...

```python
from collections import deque
from typing import Any, Optional

class DequeDS:
    """
    A wrapper class for Python's collections.deque to provide a clear
    and explicit double-ended queue interface.
    """
    def __init__(self):
        """
        Initializes an empty deque.
        """
        self._deque = deque()

    def add_first(self, item: Any) -> None:
        """
        Adds an item to the front of the deque.

        Args:
            item (Any): The item to be added.
        """
        self._deque.appendleft(item)

    def add_last(self, item: Any) -> None:
        """
        Adds an item to the back of the deque.

        Args:
            item (Any): The item to be added.
        """
        self._deque.append(item)

    def remove_first(self) -> Any:
        """
        Removes and returns the item from the front of the deque.

        Raises:
            IndexError: If the deque is empty.

        Returns:
            Any: The item from the front.
        """
        if self.is_empty():
            raise IndexError("remove_first from an empty deque")
        return self._deque.popleft()

    def remove_last(self) -> Any:
        """
        Removes and returns the item from the back of the deque.

        Raises:
            IndexError: If the deque is empty.

        Returns:
            Any: The item from the back.
        """
        if self.is_empty():
            raise IndexError("remove_last from an empty deque")
```

11.2.8.py > ...

```python
class DequeDS:
        return self._deque.pop()

    def peek_first(self) -> Any:
        """
        Returns the item at the front of the deque without removing it.

        Raises:
            IndexError: If the deque is empty.

        Returns:
            Any: The item at the front.
        """
        if self.is_empty():
            raise IndexError("peek_first from an empty deque")
        return self._deque[0]

    def peek_last(self) -> Any:
        """
        Returns the item at the back of the deque without removing it.

        Raises:
            IndexError: If the deque is empty.

        Returns:
            Any: The item at the back.
        """
        if self.is_empty():
            raise IndexError("peek_last from an empty deque")
        return self._deque[-1]

    def is_empty(self) -> bool:
        """
        Checks if the deque is empty.

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

    def __len__(self) -> int:
        """
        Returns the number of items in the deque.
        """
        return len(self._deque)

    def __str__(self) -> str:
        """
        Returns a string representation of the deque.
        """
        return f"DequeDS({list(self._deque)})"

# --- Example Usage ---
if __name__ == "__main__":
    d = DequeDS()
    print(f"Is deque empty? {d.is_empty()}") # Expected: True

    print("\nAdding 'B' and 'C' to the back...")
```

```python
    d = DequeDS()
    print(f"Is deque empty? {d.is_empty()}") # Expected: True

    print("\nAdding 'B' and 'C' to the back...")
    d.add_last("B")
    d.add_last("C")
    print(d) # Expected: DequeDS(['B', 'C'])

    print("\nAdding 'A' to the front...")
    d.add_first("A")
    print(d) # Expected: DequeDS(['A', 'B', 'C'])

    print(f"\nSize of deque: {len(d)}") # Expected: 3
    print(f"Peek first: {d.peek_first()}") # Expected: A
    print(f"Peek last: {d.peek_last()}")   # Expected: C

    print("\nRemoving from the back...")
    item = d.remove_last()
    print(f"Removed '{item}'. Current deque: {d}") # Expected: DequeDS(['A', 'B'])

    print("\nRemoving from the front...")
    item = d.remove_first()
    print(f"Removed '{item}'. Current deque: {d}") # Expected: DequeDS(['B'])

    print("\nClearing the deque...")
    d.remove_first()
    print(f"Is deque empty? {d.is_empty()}") # Expected: True
```

OUTPUT:

```
PROBLEMS   OUTPUT   DEBUG CONSOLE   TERMINAL   PORTS

PS C:\Users\ramch\OneDrive\Desktop\ai> & C:/Users/ramch/AppData/Local/Programs/Python/Python312/python.exe c:/Users/ramch/OneDrive/Desktop/ai/11.2.8.py
Is deque empty? True

Adding 'B' and 'C' to the back...
DequeDS(['B', 'C'])

Adding 'A' to the front...
DequeDS(['A', 'B', 'C'])

Size of deque: 3
Peek first: A
Peek last: C

Removing from the back...
Removed 'C'. Current deque: DequeDS(['A', 'B'])

Removing from the front...
Removed 'A'. Current deque: DequeDS(['B'])

Clearing the deque...
Is deque empty? True
PS C:\Users\ramch\OneDrive\Desktop\ai>
```

OBSERVATION:

The code generated by the AI of data structures topic of double-ended queue with the help of python to easily understand the topic accurately.

TASK-09:

Use AI to generate a comparison table of different data structures (stack,
queue, linked list, etc.) including time complexities.
Sample Input Code:
No code, prompt AI for a data structure comparison table

PROMPT:

Generate a comparative table of different data structures including time complexities .

TABLE:

Data Structure Time Complexity Comparison

Data Structure	Access (by index/key)	Search (by value)	Insertion (at end)	Insertion (at start)	Deletion (at end)	Deletion (at start)	Notes
Python List (Array)	O(1)	O(n)	O(1)	O(n)	O(1)	O(n)	Insertion/deletion at the start is slow because all other elements must be shifted.
Stack (using List)	O(n)	O(n)	O(1)	N/A	O(1)	N/A	Operations are only on the "top" (end of the list). Accessing arbitrary elements is not a standard stack operation.
Queue (using List)	O(n)	O(n)	O(1)	N/A	N/A	O(n)	`dequeue` (from the start) is inefficient. `collections.deque` is highly preferred.
Queue (using deque)	O(n)	O(n)	O(1)	N/A	N/A	O(1)	`collections.deque` is optimized for fast appends and pops from both ends.
Singly Linked List	O(n)	O(n)	O(n)	O(1)	O(n)	O(1)	Insertion/deletion at the start is fast. Finding the end requires traversing the whole list.
Doubly Linked List	O(n)	O(n)	O(1)	O(1)	O(1)	O(1)	Faster end-of-list operations than a singly linked list because it can be tracked. Uses more memory per node.
Hash Table (Dict)	O(1)	O(1)	O(1)	O(1)	O(1)	O(1)	Average case is O(1). Worst case (due to hash collisions) can be O(n).
Binary Search Tree	O(log n)	O(log n)	O(log n)	O(log n)	O(log n)	O(log n)	Assumes the tree is balanced. In the worst case (an unbalanced tree), it degrades to O(n).

TASK-10:

Your college wants to develop a Campus Resource Management System that
handles:
1. Student Attendance Tracking – Daily log of students entering/exiting
the campus.

2. Event Registration System – Manage participants in events with quick
search and removal.
3. Library Book Borrowing – Keep track of available books and their due
dates.
4. Bus Scheduling System – Maintain bus routes and stop connections.
5. Cafeteria Order Queue – Serve students in the order they arrive.

Student Task:

- For each feature, select the most appropriate data structure from the list
below:
    - o Stack
    - o Queue
    - o Priority Queue
    - o Linked List
    - o Binary Search Tree (BST)
    - o Graph
    - o Hash Table
    - o Deque
- Justify your choice in 2–3 sentences per feature.
- Implement one selected feature as a working Python program with AI-
assisted code generation.

PROMPT:

Generate the python code according to the given above details.

CODE:

```python
from typing import Any, Dict, Optional

class EventRegistration:
    """
    Manages participant registration for an event using a hash table.
    This provides fast lookups, additions, and removals of participants.
    """
    def __init__(self, event_name: str):
        """
        Initializes the registration system for a specific event.

        Args:
            event_name (str): The name of the event.
        """
        self.event_name = event_name
        # The hash table (dictionary) to store participants.
        # Key: student_id, Value: student_name
        self._participants: Dict[int, str] = {}
        print(f"Event Registration System for '{self.event_name}' is now open!")

    def register_participant(self, student_id: int, student_name: str) -> bool:
        """
        Registers a new participant for the event.

        Args:
            student_id (int): The unique ID of the student.
            student_name (str): The name of the student.

        Returns:
            bool: True if registration was successful, False if the student
                  is already registered.
        """
        if student_id in self._participants:
            print(f"-> Error: Student {student_name} (ID: {student_id}) is already registered.")
            return False

        self._participants[student_id] = student_name
        print(f"-> Success: {student_name} (ID: {student_id}) has been registered.")
        return True

    def remove_participant(self, student_id: int) -> bool:
        """
        Removes a participant from the event.

        Args:
            student_id (int): The ID of the student to remove.

        Returns:
            bool: True if the student was found and removed, False otherwise.
        """
        if student_id in self._participants:
            student_name = self._participants.pop(student_id)
            print(f"-> Success: {student_name} (ID: {student_id}) has been removed.")
            return True

        print(f"-> Error: Student with ID {student_id} not found.")
        return False

```

```python
    def find_participant(self, student_id: int) -> Optional[str]:
        """
        Searches for a participant by their student ID.

        Args:
            student_id (int): The ID of the student to find.

        Returns:
            Optional[str]: The name of the student if found, otherwise None.
        """
        return self._participants.get(student_id)

    def display_participants(self) -> None:
        """
        Displays a list of all registered participants.
        """
        print(f"\n--- Registered Participants for '{self.event_name}' ---")
        if not self._participants:
            print("No participants are currently registered.")
        else:
            for student_id, student_name in self._participants.items():
                print(f"  - ID: {student_id}, Name: {student_name}")
        print("-------------------------------------------------")

# --- Example Usage ---
if __name__ == "__main__":
    # Create a registration system for a "CodeFest 2024" event
    codefest_event = EventRegistration("CodeFest 2024")

    print("\n--- Registering Participants ---")
    codefest_event.register_participant(101, "Alice")
    codefest_event.register_participant(102, "Bob")
    codefest_event.register_participant(103, "Charlie")

    # Attempt to register a duplicate
    codefest_event.register_participant(101, "Alice")

    codefest_event.display_participants()

    print("\n--- Searching for a Participant ---")
    student_id_to_find = 102
    student_name = codefest_event.find_participant(student_id_to_find)
    if student_name:
        print(f"Found participant with ID {student_id_to_find}: {student_name}")
    else:
        print(f"Participant with ID {student_id_to_find} not found.")

    print("\n--- Removing a Participant ---")
    codefest_event.remove_participant(103) # Successful removal
    codefest_event.remove_participant(999) # Failed removal (not found)

    codefest_event.display_participants()
```

OUTPUT:

```
PS C:\Users\ramch\OneDrive\Desktop\ai> & C:/Users/ramch/AppData/Local/Programs/Python/Python312/python.exe c:/Users/ramch/OneDrive/Desktop/ai/11.2.10.py
Event Registration System for 'CodeFest 2024' is now open!

--- Registering Participants ---
-> Success: Alice (ID: 101) has been registered.
-> Success: Bob (ID: 102) has been registered.
-> Success: Charlie (ID: 103) has been registered.
-> Error: Student Alice (ID: 101) is already registered.

--- Registered Participants for 'CodeFest 2024' ---
  - ID: 101, Name: Alice
  - ID: 102, Name: Bob
  - ID: 103, Name: Charlie
-------------------------------------------------

--- Searching for a Participant ---
Found participant with ID 102: Bob

--- Removing a Participant ---
-> Success: Charlie (ID: 103) has been removed.
-> Error: Student with ID 999 not found.

--- Registered Participants for 'CodeFest 2024' ---
  - ID: 101, Name: Alice
  - ID: 102, Name: Bob
-------------------------------------------------
PS C:\Users\ramch\OneDrive\Desktop\ai>
```

TABLE:

Data Structure Selection and Justification

Here is a table that maps each system feature to the most suitable data structure and provides a justification for the choice.

Feature	Chosen Data Structure	Justification
1. Student Attendance Tracking	**Stack**	A stack is ideal for tracking entries and exits. When a student enters, their ID is pushed onto the stack; when they exit, their ID is popped. This Last-In, First-Out (LIFO) model naturally represents the most recent students on campus and can quickly show who is currently inside.
2. Event Registration System	**Hash Table**	A hash table (like a Python dictionary) is perfect for managing event participants. It allows for extremely fast $O(1)$ average-time lookups, insertions, and removals using a unique student ID as the key. This efficiency is crucial for quickly checking if a student is registered or for managing a large list of attendees.
3. Library Book Borrowing	**Binary Search Tree (BST)**	A BST, keyed on book titles or ISBNs, is a great choice for managing available books. It keeps the books in a sorted order, allowing for efficient $O(\log n)$ searching. This is much faster than a linear scan when the library has thousands of books.
4. Bus Scheduling System	**Graph**	A graph is the most natural way to model a bus network. Each bus stop can be represented as a vertex, and the routes between stops can be represented as edges. This structure allows for solving complex problems like finding the shortest path between two stops or identifying all possible routes.
5. Cafeteria Order Queue	**Queue**	A queue is the perfect data structure for this task as it follows the First-In, First-Out (FIFO) principle. Students are served in the exact order they arrive, just like a real-world line. This ensures fairness and is the most intuitive way to manage an order system.

OBSERVATION:

The AI generated the code in an efficient way according to the details given in which it include all the data structures concepts to make all easily understand . As the task contains much more information it should be handled in an efficient way.