***LAB ASSIGNMENT – 11***

***NAME : Bhavaneesh.A***

***HALL.NO : 2403A52350***

***BATCH.NO : AI 13***

***Prompt 01****:*

*Write a simple Python Stack class with push, pop, peek, and is\_empty methods. Add short comments and docstrings.*

***Code:***

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***Code explanation:***

* *class Stack: This line defines a new class named Stack.*
* *"A simple Stack class implementation."""This is a docstring that explains the purpose of the class.*
* *def \_\_init\_\_(self):: This is the constructor method. It's called when you create a new Stack object.*
  + *self.\_items = []: Inside the constructor, an empty list named \_items is initialized. This list will be used internally to store the elements of the stack. The underscore prefix (\_) is a convention to indicate that this is an internal detail of the class.*
* *def push(self, item): This method adds an item to the top of the stack.*
  + *self.\_items.append(item): The append() method of the list adds the item to the end of the \_items list, which is considered the "top" of the stack in this implementation.*
* *def pop(self):: This method removes and returns the item from the top of the stack.*
  + *if not self.is\_empty():: It first checks if the stack is not empty using the is\_empty() method.*
  + *return self.\_items.pop(): If the stack is not empty, the pop() method of the list is used to remove and return the last element (the top of the stack).*
  + *else: raise IndexError("pop from empty stack"): If the stack is empty, it raises an IndexError with a descriptive message.*
* *def peek(self):: This method returns the item at the top of the stack without removing it.*
  + *if not self.is\_empty():: It also checks if the stack is not empty.*
  + *return self.\_items[-1]: If not empty, it returns the last element of the list (\_items[-1]) using negative indexing, which accesses the last element.*
  + *else: raise IndexError("peek from empty stack"): If empty, it raises an IndexError.*
* *def is\_empty(self): This method checks if the stack is empty.*
  + *return len(self.\_items) == 0: It returns True if the length of the \_items list is 0, and False otherwise.*
* *def size(self):: This method returns the number of items in the stack.*
  + *return len(self.\_items): It simply returns the length of the \_items list.*

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***Prompt 02:***

*Create a Python Queue class using lists with enqueue, dequeue, and is\_empty methods. Then suggest a faster version using collections. Deque.*

***Code:***

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***Code explanation:  
class Queue:****: This line defines a new class named Queue.*

* ***"""A simple Queue class implementation using a list."""****: This is a docstring explaining the class's purpose and implementation detail (using a list).*
* ***def \_\_init\_\_(self):****: This is the constructor.*
  + ***self.\_items = []****: An empty list \_items is initialized to hold the queue elements.*
* ***def enqueue(self, item):****: This method adds an item to the back (rear) of the queue.*
  + ***self.\_items.append(item)****: The append() method is used to add the item to the end of the list. This is an efficient operation (O(1) on average).*
* ***def dequeue(self):****: This method removes and returns the item from the front of the queue.*
  + ***if not self.is\_empty():****: It checks if the queue is not empty.*
  + ***return self.\_items.pop(0)****: If not empty, pop(0) is used to remove and return the element at index 0 (the front of the list).****However, this operation can be inefficient (O(n))****because all subsequent elements need to be shifted to the left to fill the gap.*
  + ***else: raise IndexError("dequeue from empty queue")****: If the queue is empty, it raises an IndexError.*
* ***def is\_empty(self):****: This method checks if the queue is empty by checking if the length of the \_items list is 0.*

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***Prompt 03:***

*Make a Python singly linked list with insert\_at\_end, delete\_value, and traverse methods. Add comments to explain pointer changes.*

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***Code explanation:***

*The Node Class:*

* *class Node:: This defines the building block of the linked list. Each Node object will hold a piece of data and a reference to the next node in the sequence.*
* *def \_\_init\_\_(self, data):: This is the constructor for the Node.*
  + *self.data = data: This line stores the actual data that the node will hold.*
  + *self.next = None: This is the crucial part for linking. self.next is a pointer (or reference) to the next node in the list. When a node is initially created, it doesn't point to anything yet, so it's set to None.*

*2. The SinglyLinkedList Class:*

* *class SinglyLinkedList:: This class represents the entire linked list. It manages the sequence of nodes.*
* *def \_\_init\_\_(self):: This is the constructor for the SinglyLinkedList.*
  + *self.head = None: This initializes the head of the list to None. The head is a pointer to the very first node in the list. An empty list has no head.*
* *def insert\_at\_end(self, data):: This method adds a new node with the given data to the end of the list.*
  + *new\_node = Node(data): A new Node object is created with the provided data.*
  + *if not self.head:: This checks if the list is currently empty.*
    - *self.head = new\_node: If the list is empty, the new node becomes the head.*
    - *return: The method finishes here if the list was empty.*
  + *last\_node = self.head: If the list is not empty, a temporary pointer last\_node is set to the current head.*
  + *while last\_node.next:: This loop traverses the list until last\_node points to the last node (the one whose next pointer is None).*
    - *last\_node = last\_node.next: The last\_node pointer moves to the next node in each iteration.*
  + *last\_node.next = new\_node: Once the loop finishes, last\_node is at the end. Its next pointer is updated to point to the new\_node, effectively adding the new node to the end of the list.*
* *def delete\_value(self, value):: This method deletes the first node that contains the given value.*
  + *if not self.head:: Checks if the list is empty. If so, there's nothing to delete.*
  + *if self.head.data == value:: Checks if the head node contains the value to be deleted.*
    - *self.head = self.head.next: If the head contains the value, the head pointer is updated to point to the next node, effectively removing the original head.*
    - *return: The method finishes after deleting the head.*
  + *current\_node = self.head: If the value is not in the head, a current\_node pointer is initialized to the head.*
  + *while current\_node.next and current\_node.next.data != value:: This loop traverses the list until either the next node exists and its data matches the value, or the end of the list is reached.*
    - *current\_node = current\_node.next: The current\_node pointer moves to the next node.*
  + *if current\_node.next:: After the loop, this checks if a node with the value was found (i.e., current\_node.next is not None).*
    - *current\_node.next = current\_node.next.next: If the node was found, the next pointer of the node before the one to be deleted (current\_node) is updated to point to the node after the one to be deleted (current\_node.next.next). This bypasses the node to be deleted, removing it from the list's sequence.*
* *def traverse(self):: This method goes through the list from beginning to end and prints the data of each node.*
  + *current\_node = self.head: A current\_node pointer starts at the head.*
  + *while current\_node:: This loop continues as long as current\_node is not None (meaning there are still nodes to visit).*
    - *print(current\_node.data, end=" -> "): The data of the current node is printed, followed by " -> ". end=" -> " prevents a newline after each print, keeping the output on one line.*
    - *current\_node = current\_node.next: The current\_node pointer moves to the next node.*
  + *print("None"): After the loop finishes (when current\_node becomes None), "None" is printed to indicate the end of the list.*

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***Prompt 04:***

*Write a Python BST with insert, search, and inorder\_traversal methods. Add comments for recursion and traversal.*

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***Code explanation:***

1. ***Node Class:****This class represents a single node within the BST. Each node has:*
   * *key: The value stored in the node.*
   * *left: A reference to the left child node.*
   * *right: A reference to the right child node.*
2. ***BST Class:****This class represents the entire Binary Search Tree.*
   * *\_\_init\_\_(self): The constructor initializes an empty BST by setting the root to None.*
   * *insert(self, key): This method inserts a new node with the given key into the BST. It handles the case of an empty tree and then calls a recursive helper method \_insert\_recursive.*
   * *\_insert\_recursive(self, current\_node, key): This is a recursive helper function for insertion. It compares the key to the current\_node's key and moves down the left or right subtree until it finds an appropriate place to insert the new node.*
   * *search(self, key): This method searches for a node with the given key in the BST. It calls a recursive helper method \_search\_recursive.*
   * *\_search\_recursive(self, current\_node, key): This is a recursive helper function for searching. It checks if the current\_node is the target node or if the target is in the left or right subtree and recursively searches accordingly.*
   * *inorder\_traversal(self): This method performs an in-order traversal of the BST, which visits nodes in ascending order of their keys. It calls a recursive helper method \_inorder\_recursive.*
   * *\_inorder\_recursive(self, current\_node, result): This is a recursive helper function for in-order traversal. It visits the left subtree, then the current node, and then the right subtree, appending the node's key to the result list.*
3. ***Example Usage:****The code then demonstrates how to use the BST class by:*
   * *Creating a BST instance.*
   * *Inserting several values into the tree.*
   * *Performing an in-order traversal and printing the result.*
   * *Searching for existing and non-existing keys and printing the results.*

***Prompt 05:***

*Implement a Python graph using an adjacency list with BFS and DFS methods. Add short comments to explain how each traversal works.*

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***Code explanation:***

1. ***Graph Class:***
   * *\_\_init\_\_(self): The constructor initializes an empty graph using defaultdict(list). This creates a dictionary where keys are nodes and values are lists of their neighbors. If a node is accessed that isn't already in the dictionary, a new entry is created with an empty list as its value.*
   * *add\_edge(self, u, v): This method adds a directed edge from node u to node v. It appends v to the list of neighbors for u. The commented-out line self.graph[v].append(u) would be included for an undirected graph to add the edge in both directions.*
2. ***bfs(self, start\_node):***
   * *This method performs a Breadth-First Search starting from the start\_node.*
   * *It uses a deque (double-ended queue) to manage the nodes to visit. BFS explores the graph level by level.*
   * *visited is a set to keep track of nodes that have already been visited to avoid infinite loops.*
   * *The while queue: loop continues as long as there are nodes to visit.*
   * *queue.popleft() removes the node at the beginning of the queue (FIFO - First-In, First-Out).*
   * *It then iterates through the neighbors of the current node and adds unvisited neighbors to the visited set and the queue.*
   * *The result list stores the nodes in the order they are visited during the traversal.*
3. ***dfs(self, start\_node):***
   * *This method performs a Depth-First Search starting from the start\_node.*
   * *It uses recursion (implicitly through function calls) to explore as deep as possible along each branch before backtracking.*
   * *visited is a set to keep track of visited nodes.*
   * *The inner function \_dfs\_recursive(node) is the recursive helper.*
   * *It marks the current node as visited and adds it to the result list.*
   * *Then, it iterates through the neighbors of the current node. If a neighbor hasn't been visited, it recursively calls \_dfs\_recursive on that neighbor.*
4. ***Example Usage:****The code demonstrates how to create a Graph instance, add edges to define the graph structure, and then perform BFS and DFS starting from a specific node (node 2 in this case), printing the order of visited nodes for each traversal.*