# ASSIGNMENT-11.1

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**Task Description #1 – Stack Implementation**

Task: Use AI to generate a Stack class with push, pop, peek, and is_empty methods.

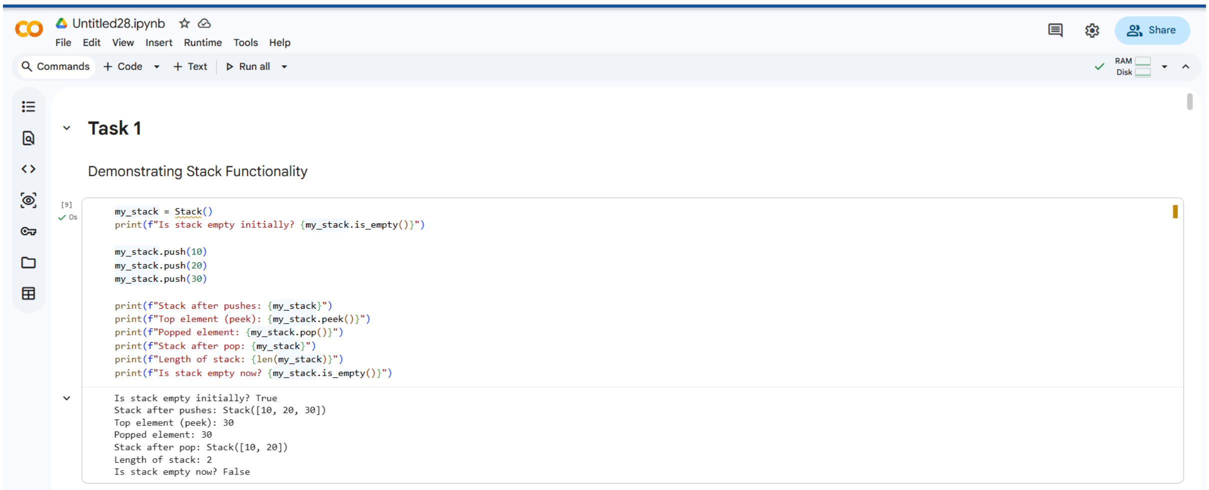
Sample Input Code:

class Stack:

pass

Expected Output:

• A functional stack implementation with all required methods and docstrings.




**EXPLANATION:**

A stack follows the principle LIFO (Last In, First Out).

The last element inserted is the first one removed.

We use a Python list (self.items) to store elements.

**Task Description #2 – Queue Implementation**

Task: Use AI to implement a Queue using Python lists.

Sample Input Code:

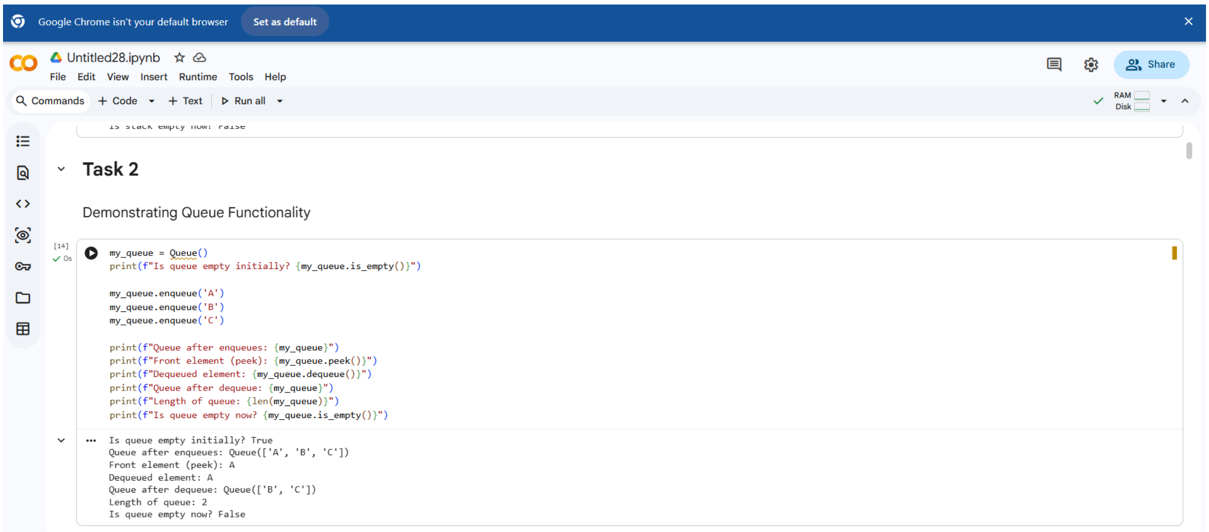
class Queue:

pass

Expected Output:

• FIFO-based queue class with enqueue, dequeue, peek, and size

methods.




**EXPLANATION:**

A queue works on the principle FIFO (First In, First Out).

The first element inserted is the first one removed.

We use a Python list called self.items to store elements.

**Task Description #3 – Linked List**

Task: Use AI to generate a Singly Linked List with insert and display

methods.

Sample Input Code:

class Node:

pass

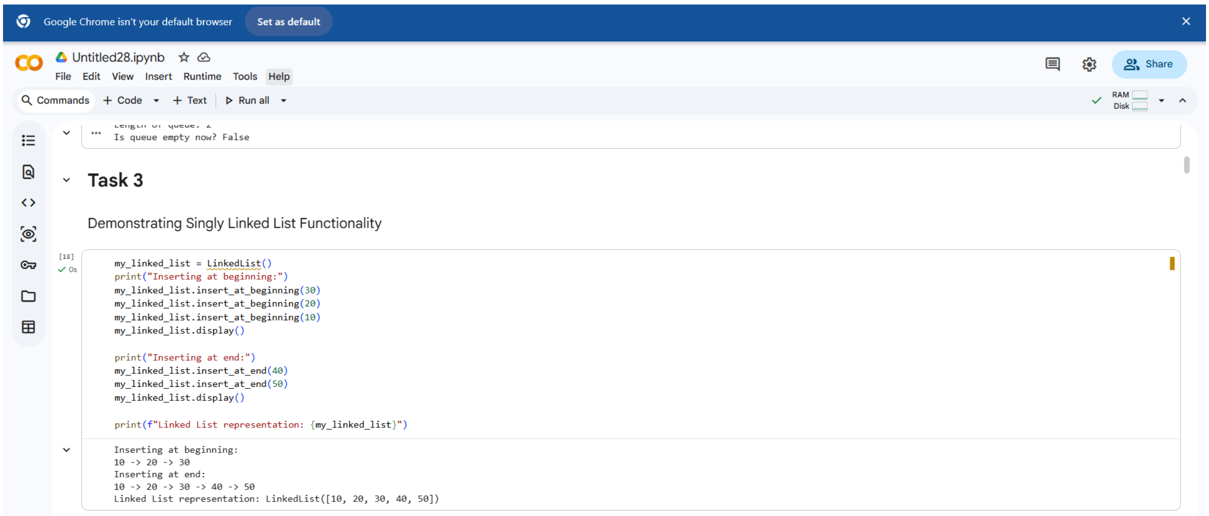
class LinkedList:

pass

Expected Output:

• A working linked list implementation with clear method

Documentation.




**EXPLANATION** (Linked List):

A singly linked list is a collection of nodes where:

Each node stores data

And a reference to the next node

1 insert(data)

Creates a new node

Traverses to the last node

**Task Description #4 – Binary Search Tree (BST)**

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

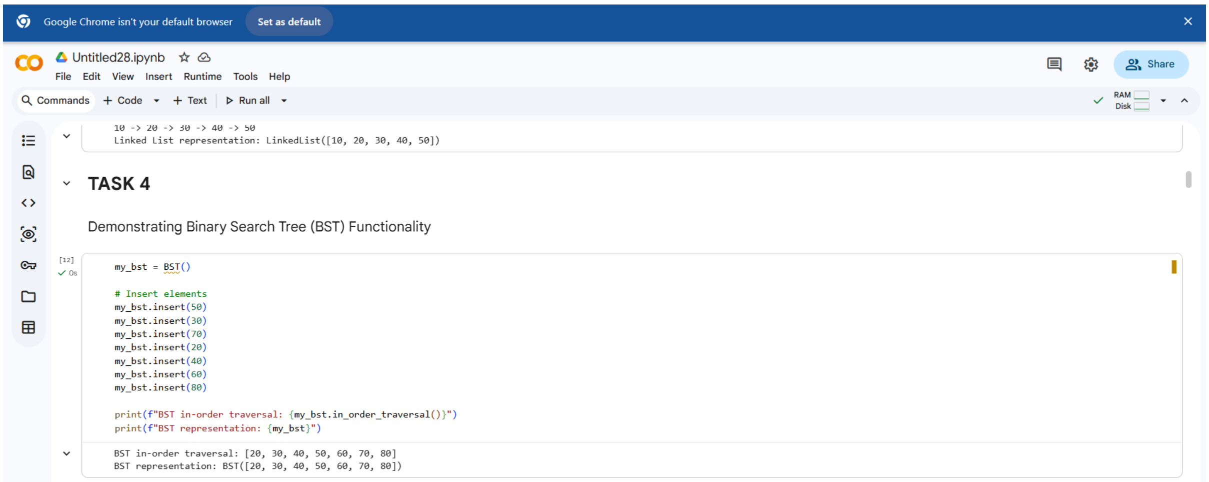
Sample Input Code:

class BST:

pass

Expected Output:

• BST implementation with recursive insert and traversal methods.




## EXPLANATION:

A Binary Search Tree (BST) stores values such that:

Left child contains smaller values

Right child contains larger values

Insert (recursive):

If the tree is empty, the first value becomes the root.

Otherwise, compare the value with the current node:

Go left if smaller

Go right if larger

Repeat this process recursively until an empty spot is found and insert there.

In-order traversal:

Visits nodes in the order: Left → Root → Right. This prints the elements in sorted order. So, the BST keeps data ordered and allows efficient insertion and sorted traversal.

### Task Description #5 – Hash Table

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

delete methods.

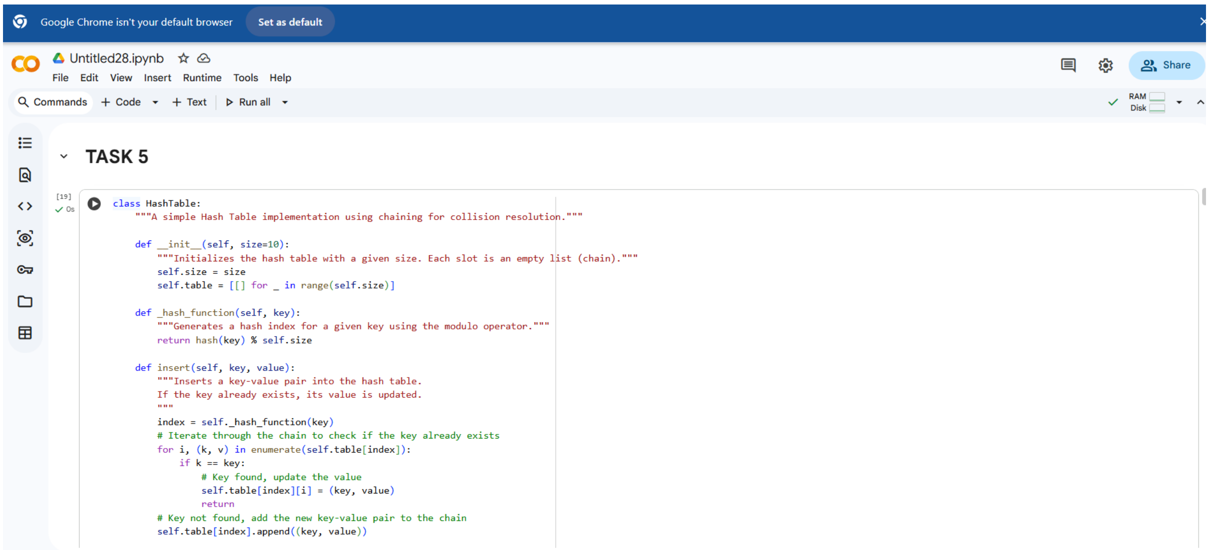
Sample Input Code:

class HashTable:

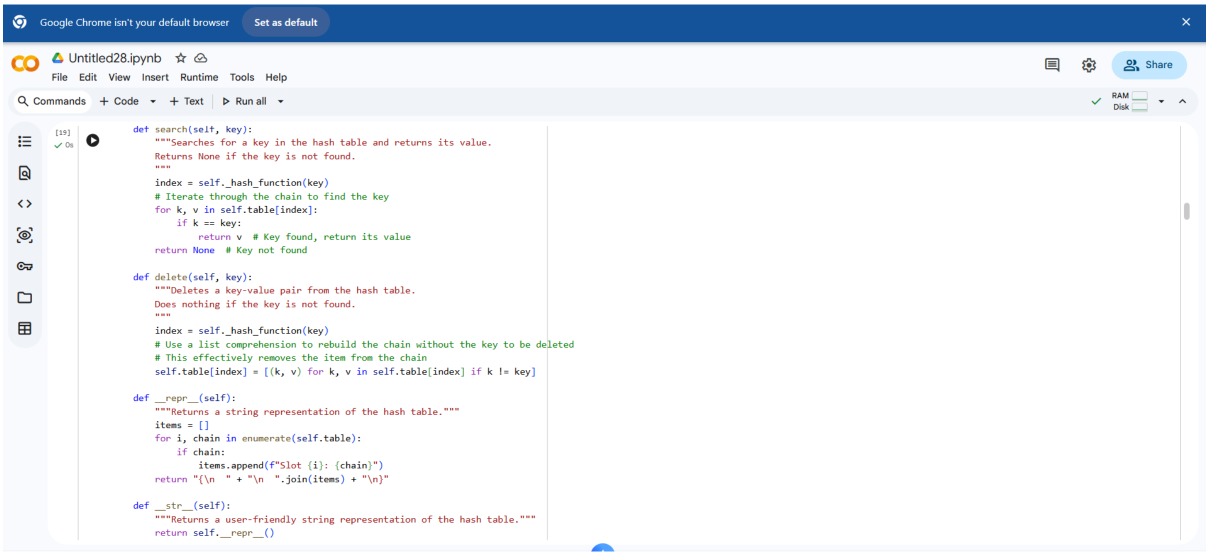
pass

Expected Output:

• Collision handling using chaining, with well-commented methods.




```python
class HashTable:
    """A simple Hash Table implementation using chaining for collision resolution."""

    def __init__(self, size=10):
        """Initializes the hash table with a given size. Each slot is an empty list (chain)."""
        self.size = size
        self.table = [[] for _ in range(self.size)]

    def _hash_function(self, key):
        """Generates a hash index for a given key using the modulo operator."""
        return hash(key) % self.size

    def insert(self, key, value):
        """Inserts a key-value pair into the hash table.
        If the key already exists, its value is updated.
        """
        index = self._hash_function(key)
        # Iterate through the chain to check if the key already exists
        for i, (k, v) in enumerate(self.table[index]):
            if k == key:
                # Key found, update the value
                self.table[index][i] = (key, value)
                return
        # Key not found, add the new key-value pair to the chain
        self.table[index].append((key, value))
```




```python
    def search(self, key):
        """Searches for a key in the hash table and returns its value.
        Returns None if the key is not found.
        """
        index = self._hash_function(key)
        # Iterate through the chain to find the key
        for k, v in self.table[index]:
            if k == key:
                return v  # Key found, return its value
        return None  # Key not found

    def delete(self, key):
        """Deletes a key-value pair from the hash table.
        Does nothing if the key is not found.
        """
        index = self._hash_function(key)
        # Use a list comprehension to rebuild the chain without the key to be deleted
        # This effectively removes the item from the chain
        self.table[index] = [(k, v) for k, v in self.table[index] if k != key]

    def __repr__(self):
        """Returns a string representation of the hash table."""
        items = []
        for i, chain in enumerate(self.table):
            if chain:
                items.append(f"Slot {i}: {chain}")
        return "{\n  " + "\n  ".join(items) + "\n}"

    def __str__(self):
        """Returns a user-friendly string representation of the hash table."""
        return self.__repr__()
```

## EXPLANATION:

A hash table stores data using a key-value pair.

A hash function converts the key into an index.

## Task Description #6 – Graph Representation

Task: Use AI to implement a graph using an adjacency list.

Sample Input Code:

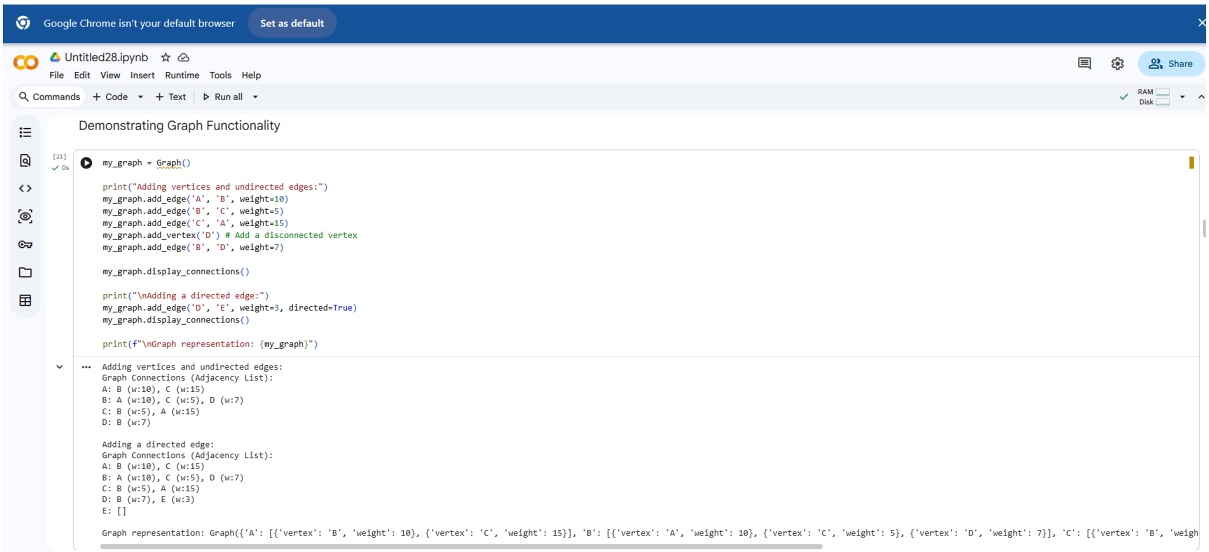
class Graph:

pass

Expected Output:

• Graph with methods to add vertices, add edges, and display

Connections.




**EXPLANATION:**

A graph consists of:

Vertices (nodes)

Edges (connections)

Using an adjacency list, each vertex stores a list of its connected vertices.

**Task Description #7 – Priority Queue**

Task: Use AI to implement a priority queue using Python's heapq

module.

Sample Input Code:

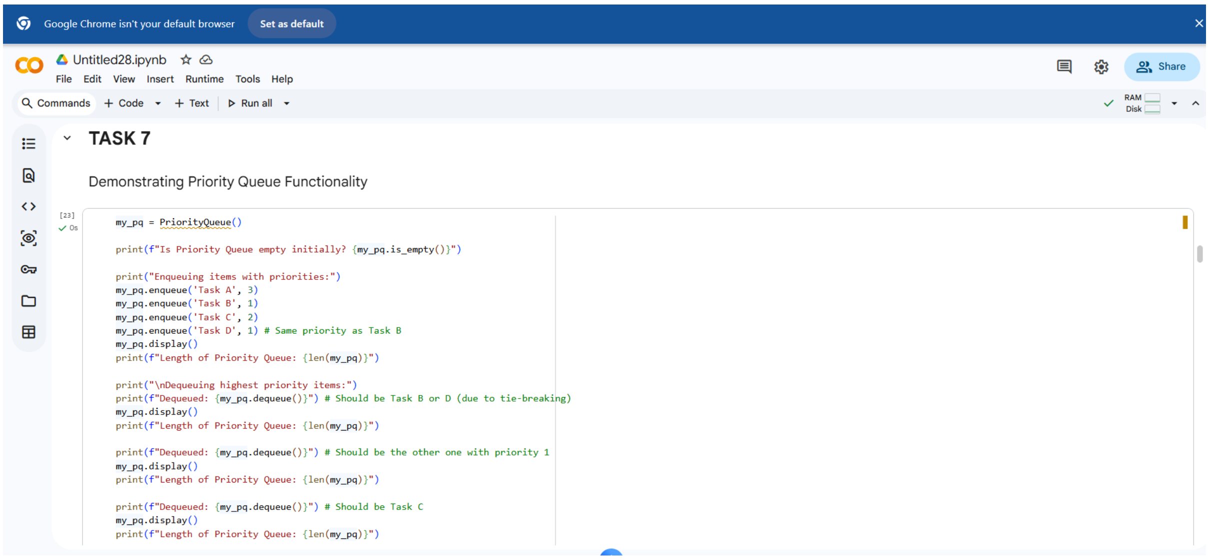
class PriorityQueue:

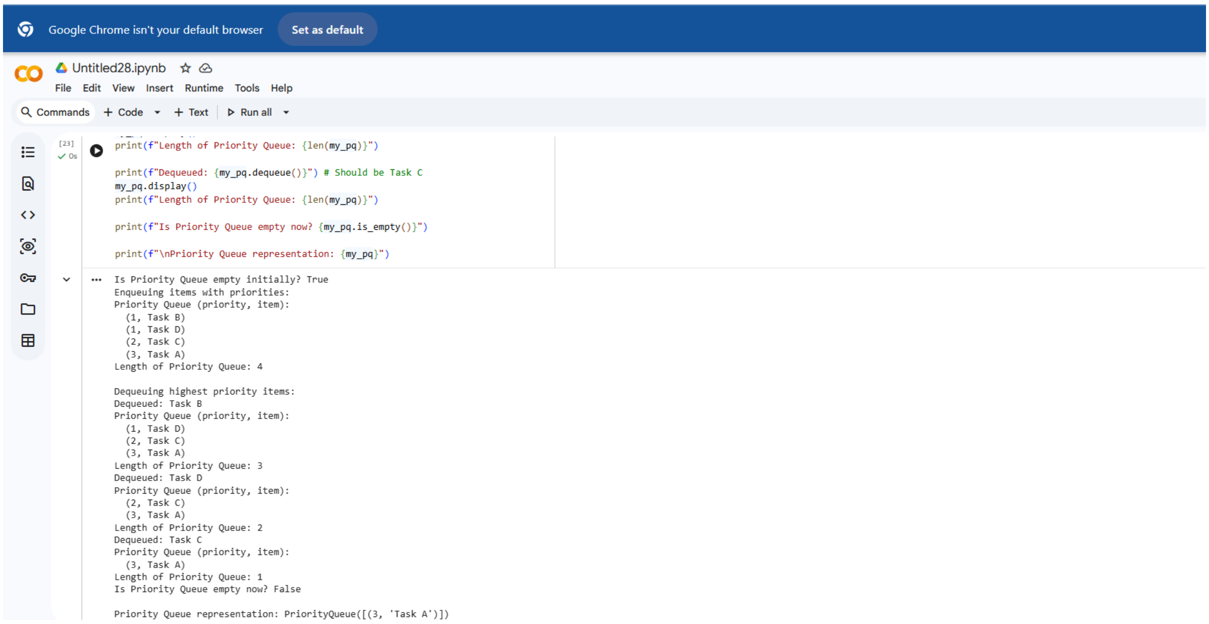
pass

Expected Output:

• Implementation with enqueue (priority), dequeue (highest priority),

and display methods.




## EXPLANATION:

A priority queue stores elements with a priority value.

The element with the highest priority is removed first.

Python’s heapq provides a min-heap, so to get highest priority first, we:

Store priority as negative value.

This makes larger priorities come out first.

### Task Description #8 – Deque

Task: Use AI to implement a double-ended queue using

collections.deque.

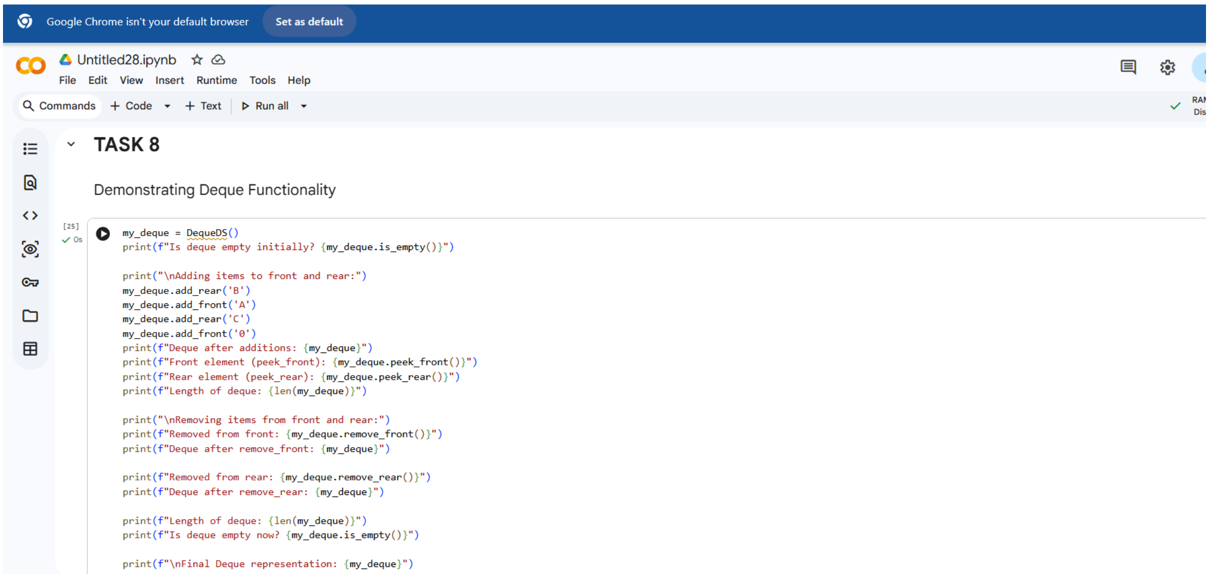
Sample Input Code:

class DequeDS:

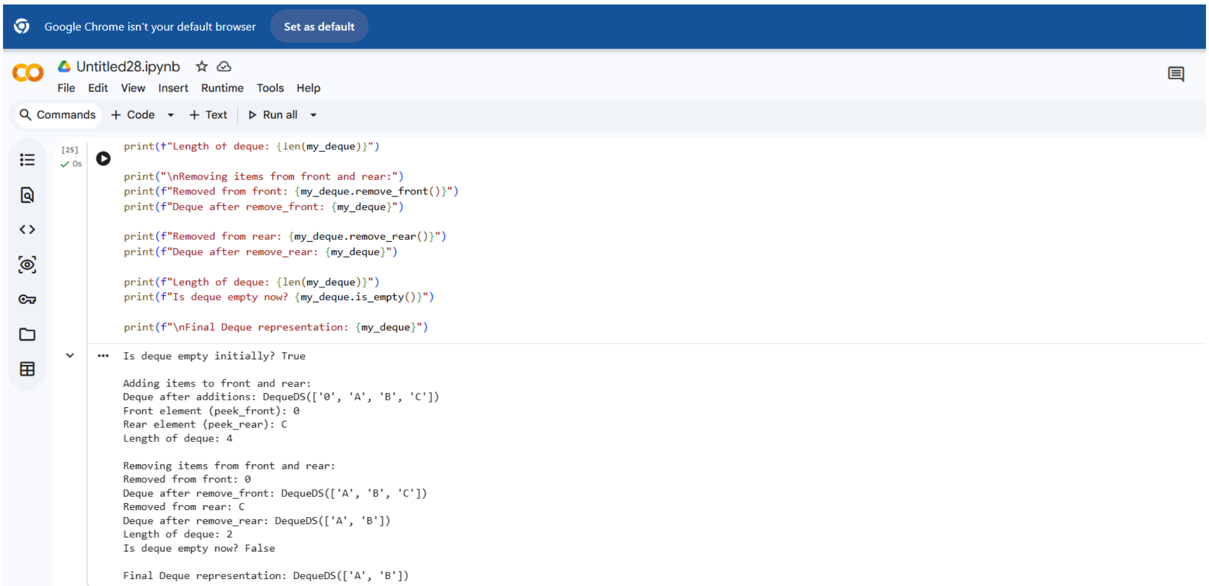
pass

Expected Output:

• Insert and remove from both ends with docstrings.




```python
my_deque = DequeDS()
print(f"Is deque empty initially? {my_deque.is_empty()}")

print("\nAdding items to front and rear:")
my_deque.add_rear('B')
my_deque.add_front('A')
my_deque.add_rear('C')
my_deque.add_front('0')
print(f"Deque after additions: {my_deque}")
print(f"Front element (peek_front): {my_deque.peek_front()}")
print(f"Rear element (peek_rear): {my_deque.peek_rear()}")
print(f"Length of deque: {len(my_deque)}")

print("\nRemoving items from front and rear:")
print(f"Removed from front: {my_deque.remove_front()}")
print(f"Deque after remove_front: {my_deque}")

print(f"Removed from rear: {my_deque.remove_rear()}")
print(f"Deque after remove_rear: {my_deque}")

print(f"Length of deque: {len(my_deque)}")
print(f"Is deque empty now? {my_deque.is_empty()}")

print(f"\nFinal Deque representation: {my_deque}")
```




```python
print(f"Length of deque: {len(my_deque)}")

print("\nRemoving items from front and rear:")
print(f"Removed from front: {my_deque.remove_front()}")
print(f"Deque after remove_front: {my_deque}")

print(f"Removed from rear: {my_deque.remove_rear()}")
print(f"Deque after remove_rear: {my_deque}")

print(f"Length of deque: {len(my_deque)}")
print(f"Is deque empty now? {my_deque.is_empty()}")

print(f"\nFinal Deque representation: {my_deque}")
```

```
Is deque empty initially? True

Adding items to front and rear:
Deque after additions: DequeDS(['0', 'A', 'B', 'C'])
Front element (peek_front): 0
Rear element (peek_rear): C
Length of deque: 4

Removing items from front and rear:
Removed from front: 0
Deque after remove_front: DequeDS(['A', 'B', 'C'])
Removed from rear: C
Deque after remove_rear: DequeDS(['A', 'B'])
Length of deque: 2
Is deque empty now? False

Final Deque representation: DequeDS(['A', 'B'])
```

## EXPLANATION:

A Deque (Double-Ended Queue) allows:

Insertion at front and rear

Deletion from front and rear

It is more flexible than a normal queue.

Using collections.deque:

appendleft() → insert front

append() → insert rear

popleft() → remove front

pop() → remove rear

All operations are O(1) (efficient).

**Task Description #9 Real-Time Application Challenge –** Choose the Right Data Structure

Scenario:

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.

Expected Output:

• A table mapping feature → chosen data structure → justification.

• A functional Python program implementing the chosen feature with comments and docstrings.

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I'll start by generating the table for **Feature-Data Structure Mapping and Justification**.

```
%%write_and_execute_cell
# Feature-Data Structure Mapping and Justification

print("### Campus Feature to Data Structure Mapping")
print("Below is a table outlining common campus features, the most suitable data structure for each, and a brief justification fc
print("\n| Campus Feature               | Data Structure       | Justification
print("|-----------------------------|---------------------|------------------------------------------------------------------------
print("| Cafeteria Order Queue        | Queue               | Orders are processed in a First-In, First-Out (FIFO) manner. A Que
print("| Student Management System    | Hash Table          | Enables quick insertion, deletion, and retrieval of student record
print("| Course Enrollment System     | Graph               | Course prerequisites and dependencies can be effectively modeled a
print("| Campus Navigation (Shortest Path) | Graph            | The campus layout (buildings, paths) can be represented as a gra
print("| Book Lending System (Library)| Binary Search Tree  | Books can be stored and retrieved efficiently by unique identifier
print("| Event Scheduling (Priority)  | Priority Queue      | Events often have different levels of urgency or importance. A Pri
print("| Undo/Redo Functionality      | Stack               | Actions are added and removed in a Last-In, First-Out (LIFO) manne
print("| Recent Activity Feed         | Deque               | New activities are added to one end, and older activities can be e
```

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```python
class CafeteriaOrderQueue:
    """Simulates a cafeteria order queue using the Queue data structure."""

    def __init__(self):
        self.order_queue = Queue()
        print("Cafeteria Order Queue initialized.")

    def place_order(self, order_details):
        """Adds a new order to the queue."""
        print(f"Placing order: {order_details}")
        self.order_queue.enqueue(order_details)
        self.display_queue_status()

    def fulfill_order(self):
        """Removes and returns the next order to be fulfilled."""
        if not self.order_queue.is_empty():
            fulfilled_order = self.order_queue.dequeue()
            print(f"Fulfilling order: {fulfilled_order}")
            self.display_queue_status()
            return fulfilled_order
        else:
            print("No orders in the queue to fulfill.")
            return None

    def display_queue_status(self):
        """Prints the current status of the order queue."""
        print(f"Current orders in queue (length {len(self.order_queue)}): {self.order_queue}")
        if not self.order_queue.is_empty():
            print(f"Next order to be fulfilled: {self.order_queue.peek()}")
        print("---------------------------------------")

# --- Simulation of Cafeteria Order Process ---
print("\n--- Simulating Cafeteria Order Process ---")
my_cafeteria = CafeteriaOrderQueue()
```

```python
my_cafeteria = CafeteriaOrderQueue()

# Students placing orders
my_cafeteria.place_order("Student A - Pizza with Coke")
my_cafeteria.place_order("Student B - Burger with Fries")
my_cafeteria.place_order("Student C - Salad with Water")
my_cafeteria.place_order("Student D - Pasta")

# Cafeteria fulfilling orders
print("\n--- Fulfilling Orders ---")
my_cafeteria.fulfill_order()
my_cafeteria.fulfill_order()

# Another student places an order while others are being served
my_cafeteria.place_order("Student E - Sandwich")

my_cafeteria.fulfill_order()
my_cafeteria.fulfill_order()
my_cafeteria.fulfill_order()

# Try to fulfill an order when the queue is empty
my_cafeteria.fulfill_order()
```

```
--- Simulating Cafeteria Order Process ---
Cafeteria Order Queue initialized.
Placing order: Student A - Pizza with Coke
Current orders in queue (length 1): Queue(['Student A - Pizza with Coke'])
Next order to be fulfilled: Student A - Pizza with Coke
----------------------------------------
Placing order: Student B - Burger with Fries
Current orders in queue (length 2): Queue(['Student A - Pizza with Coke', 'Student B - Burger with Fries'])
Next order to be fulfilled: Student A - Pizza with Coke
----------------------------------------
Placing order: Student C - Salad with Water
```

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```
Placing order: Student B - Burger with Fries
Current orders in queue (length 2): Queue(['Student A - Pizza with Coke', 'Student B - Burger with Fries'])
Next order to be fulfilled: Student A - Pizza with Coke
----------------------------------------
Placing order: Student C - Salad with Water
Current orders in queue (length 3): Queue(['Student A - Pizza with Coke', 'Student B - Burger with Fries', 'Student C - Salad with Water'])
Next order to be fulfilled: Student A - Pizza with Coke
----------------------------------------
Placing order: Student D - Pasta
Current orders in queue (length 4): Queue(['Student A - Pizza with Coke', 'Student B - Burger with Fries', 'Student C - Salad with Water', 'Student D - Pasta'])
Next order to be fulfilled: Student A - Pizza with Coke
----------------------------------------

--- Fulfilling Orders ---
Fulfilling order: Student A - Pizza with Coke
Current orders in queue (length 3): Queue(['Student B - Burger with Fries', 'Student C - Salad with Water', 'Student D - Pasta'])
Next order to be fulfilled: Student B - Burger with Fries
----------------------------------------
Fulfilling order: Student B - Burger with Fries
Current orders in queue (length 2): Queue(['Student C - Salad with Water', 'Student D - Pasta'])
Next order to be fulfilled: Student C - Salad with Water
----------------------------------------
Placing order: Student E - Sandwich
Current orders in queue (length 3): Queue(['Student C - Salad with Water', 'Student D - Pasta', 'Student E - Sandwich'])
Next order to be fulfilled: Student C - Salad with Water
----------------------------------------
Fulfilling order: Student C - Salad with Water
Current orders in queue (length 2): Queue(['Student D - Pasta', 'Student E - Sandwich'])
Next order to be fulfilled: Student D - Pasta
----------------------------------------
Fulfilling order: Student D - Pasta
Current orders in queue (length 1): Queue(['Student E - Sandwich'])
Next order to be fulfilled: Student E - Sandwich
----------------------------------------
Fulfilling order: Student E - Sandwich
Current orders in queue (length 0): Queue([])
----------------------------------------
No orders in the queue to fulfill.
```

## EXPLANATION:

The cafeteria system uses a Queue because it follows the First In, First Out (FIFO) rule.

Students who arrive first are served first.

The program supports adding orders, serving orders, and displaying pending orders.

**Task Description #10: Smart E-Commerce Platform** – Data Structure

Challenge

An e-commerce company wants to build a Smart Online Shopping System

with:

1. Shopping Cart Management – Add and remove products dynamically.

2. Order Processing System – Orders processed in the order they are placed.

3. Top-Selling Products Tracker – Products ranked by sales count.

4. Product Search Engine – Fast lookup of products using product ID.

5. Delivery Route Planning – Connect warehouses and delivery locations.

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.

Expected Output:

• A table mapping feature → chosen data structure → justification.

• A functional Python program implementing the chosen feature with comments and docstrings.

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[27]

```python
class OrderProcessingSystem:
    """Simulates an order processing system using the Queue data structure."""

    def __init__(self):
        self.order_queue = Queue()
        print("Order Processing System initialized.")

    def place_order(self, order_details):
        """Adds a new order to the queue."""
        print(f"Placing order: {order_details}")
        self.order_queue.enqueue(order_details)
        self.display_queue_status()

    def process_order(self):
        """Removes and returns the next order to be processed."""
        if not self.order_queue.is_empty():
            processed_order = self.order_queue.dequeue()
            print(f"Processing order: {processed_order}")
            self.display_queue_status()
            return processed_order
        else:
            print("No orders in the queue to process.")
            return None

    def display_queue_status(self):
        """Prints the current status of the order queue."""
        print(f"Current orders in queue (length {len(self.order_queue)}): {self.order_queue}")
        if not self.order_queue.is_empty():
            print(f"Next order to be processed: {self.order_queue.peek()}")
        print("----------------------------------------")

print("OrderProcessingSystem class defined.")
```

```
OrderProcessingSystem class defined.
```

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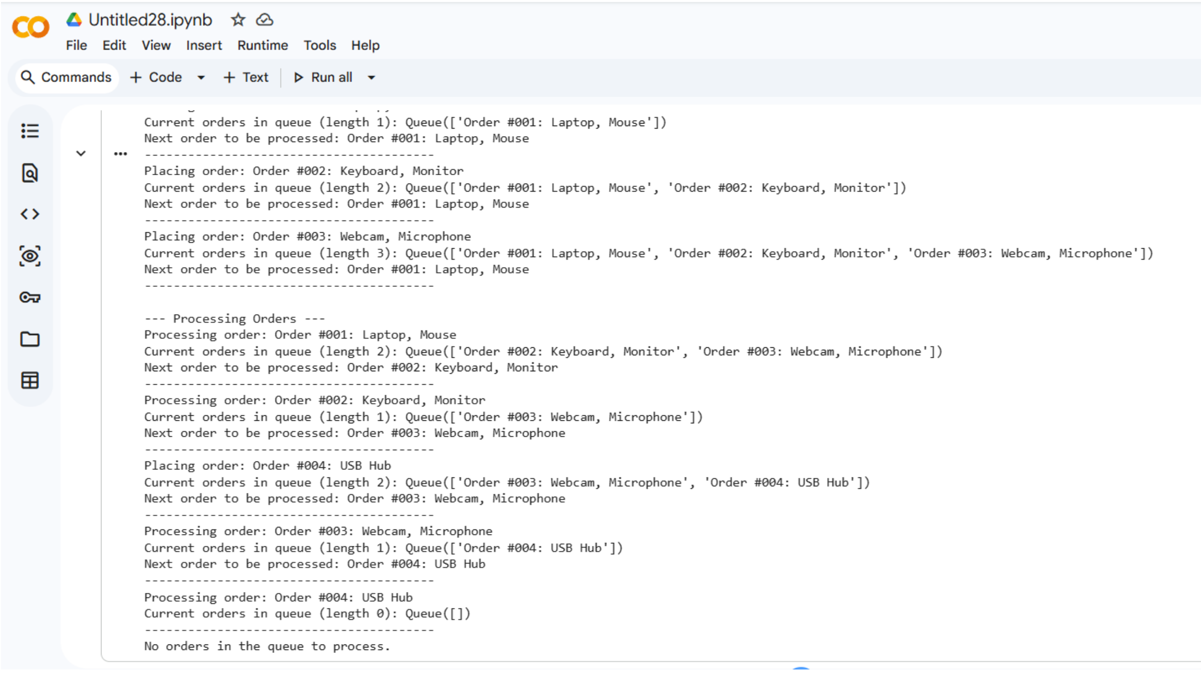
[28]

```python
print("\n--- Simulating Order Processing System ---")
my_order_system = OrderProcessingSystem()

# Simulate customers placing orders
my_order_system.place_order("Order #001: Laptop, Mouse")
my_order_system.place_order("Order #002: Keyboard, Monitor")
my_order_system.place_order("Order #003: Webcam, Microphone")

# Simulate processing some orders
print("\n--- Processing Orders ---")
my_order_system.process_order()
my_order_system.process_order()

# Another order comes in while others are being processed
my_order_system.place_order("Order #004: USB Hub")

my_order_system.process_order()
my_order_system.process_order()

# Attempt to process an order when the queue is empty
my_order_system.process_order()
```

```
--- Simulating Order Processing System ---
Order Processing System initialized.
Placing order: Order #001: Laptop, Mouse
Current orders in queue (length 1): Queue(['Order #001: Laptop, Mouse'])
Next order to be processed: Order #001: Laptop, Mouse
---------------------------------------
Placing order: Order #002: Keyboard, Monitor
```




**EXPLANATION:**

The product search system uses a Hash Table because product IDs can be used as keys for instant lookup.

Insertion, search, and deletion operations are very fast (average O(1)).

This makes it suitable for large-scale e-commerce platforms with thousands of products.