Experiment-3

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Section: 22BET_IOT-702 'A'
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Sub Name: Advanced Programming Lab-2
Subject Code: 22ITP-351

Problem 1

1. Aim:

To implement and comprehend a program that identifies the presence of a cycle in a linked list using Floyd's Cycle Detection Algorithm (Tortoise and Hare approach).

2. Objective:

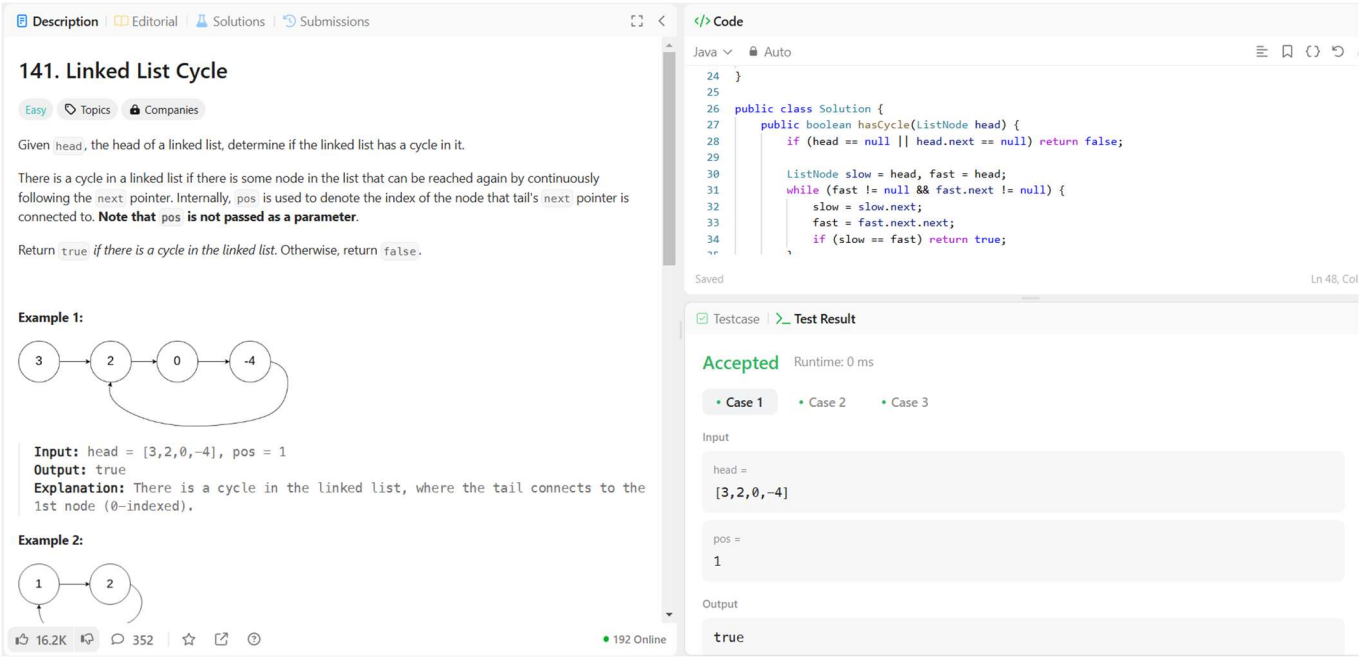
- To develop skills in identifying and solving problems involving cyclic linked lists.
- To improve proficiency in implementing algorithms in Java for data structures.

3. Code:

```
class ListNode {
int val;
ListNode next;
ListNode(int x) {
val = x;
next = null;
}

public static ListNode deserialize(String data) {
if (data == null || data.isEmpty() || data.equals("[]")) return null;
String[] values = data.replace("[", "").replace("]", "").split(",");
ListNode dummy = new ListNode(0);
```

```
ListNode current = dummy;

for (String value : values) {
current.next = new ListNode(Integer.parseInt(value.trim()));
current = current.next;
}
return dummy.next;
}
}
public class Solution {
public boolean hasCycle(ListNode head) {
if (head == null || head.next == null) return false;

ListNode slow = head, fast = head;
while (fast != null && fast.next != null) {
slow = slow.next;
fast = fast.next.next;
if (slow == fast) return true;
}
return false;
}

public static void main(String[] args) {
String input = "[3,2,0,-4]";
ListNode head = ListNode.deserialize(input);
Solution solution = new Solution();
boolean result = solution.hasCycle(head);
System.out.println("Has Cycle: " + result);
}
}
```

4. Output:



5. Learning Outcomes:

- Understand the concept and application of Floyd's Cycle Detection Algorithm for detecting cycles in linked lists.
- Learn to implement the algorithm efficiently and explain its working principle.
- Develop skills to test and debug the code for various cases, including empty lists, single-node lists, and cyclic lists.
- Analyze the algorithm's time and space complexity for better optimization.

Problem 2

1. Aim:

To develop a program that reverses a specified section of a singly linked list between the given positions left and right.

2. Objective:

- Gain proficiency in traversing and manipulating a singly linked list using pointers.
- Understand and implement in-place reversal of a specific sublist within a linked list.

3. Code:

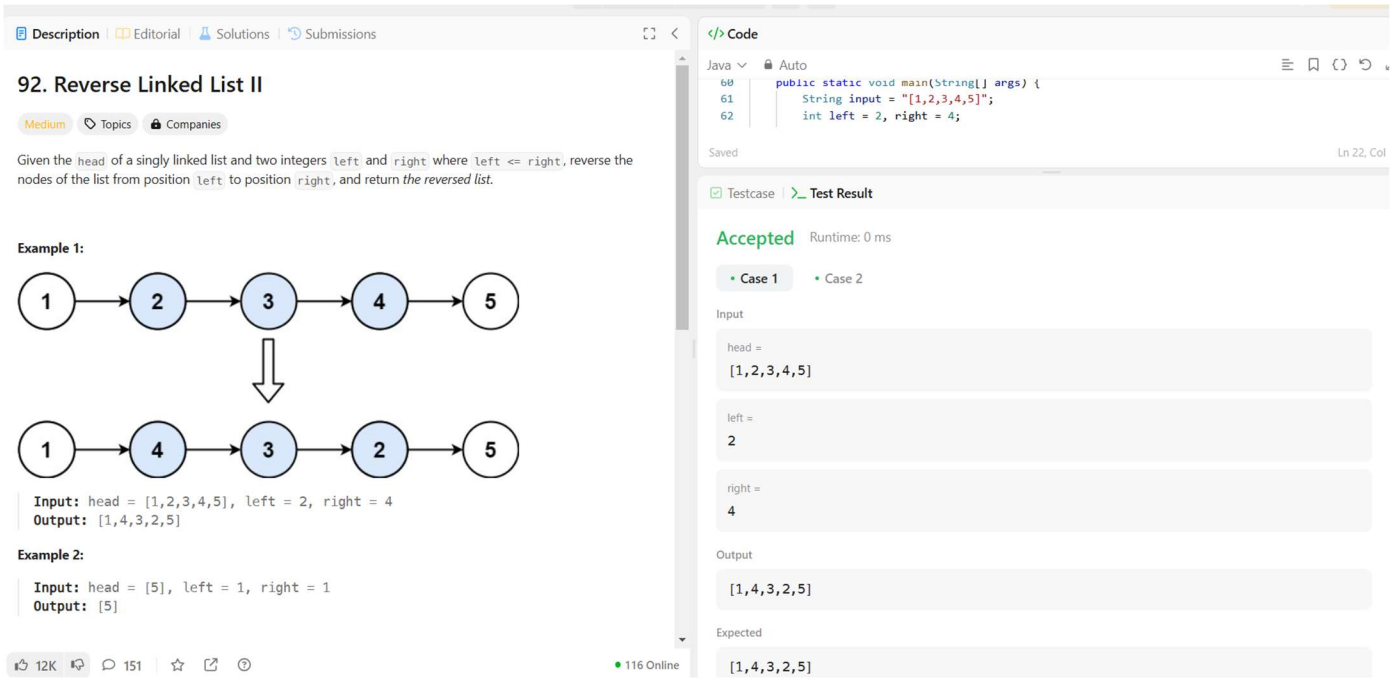
```
class ListNode {

int val;

ListNode next;

ListNode(int val) {

this.val = val;

this.next = null;

}

public static ListNode deserialize(String data) {

if (data == null || data.isEmpty() || data.equals("[]")) return null;

String[] values = data.replace("[", "").replace("]", "").split(",");

ListNode dummy = new ListNode(0);

ListNode current = dummy;
```

```
for (String value : values) {
current.next = new ListNode(Integer.parseInt(value.trim()));
current = current.next;
}
return dummy.next;
}
public static void printList(ListNode head) {
while (head != null) {
System.out.print(head.val + " -> ");
head = head.next;
}
System.out.println("null");
}
}
public class Solution {
public ListNode reverseBetween(ListNode head, int left, int right) {
if (head == null || left == right) return head;
ListNode dummy = new ListNode(0);
dummy.next = head;
ListNode prev = dummy;
for (int i = 1; i < left; i++) {
prev = prev.next;
```

```
}

ListNode curr = prev.next;

ListNode next;

ListNode prevReversed = null;

for (int i = 0; i <= right - left; i++) {

next = curr.next;

curr.next = prevReversed;

prevReversed = curr;

curr = next;

}

prev.next.next = curr;

prev.next = prevReversed;

return dummy.next;

}

public static void main(String[] args) {

String input = "[1,2,3,4,5]"; // Example input

int left = 2, right = 4;

ListNode head = ListNode.deserialize(input);

System.out.println("Original List:");

ListNode.printList(head);

Solution solution = new Solution();

head = solution.reverseBetween(head, left, right);
```

```
System.out.println("Reversed List:");

ListNode.printList(head);

}

}
```

4. Output:



5.Learning Outcomes:

- Understand and implement Floyd's Cycle Detection Algorithm for linked list cycle detection.
- Learn to traverse and manipulate a singly linked list efficiently using pointers.
- Develop the ability to reverse a specific portion of a linked list in-place.
- Enhance debugging skills by handling edge cases like empty lists, single-node lists, and cyclic lists.

Problem 3

1.Aim:

To develop a program that efficiently rotates a singly linked list to the right by a specified number of positions, while handling edge cases and large inputs effectively.

2. Objective:

- Understand the concept and implementation of rotating a singly linked list.
- Practice in-place modifications, including creating and breaking circular connections in linked lists.

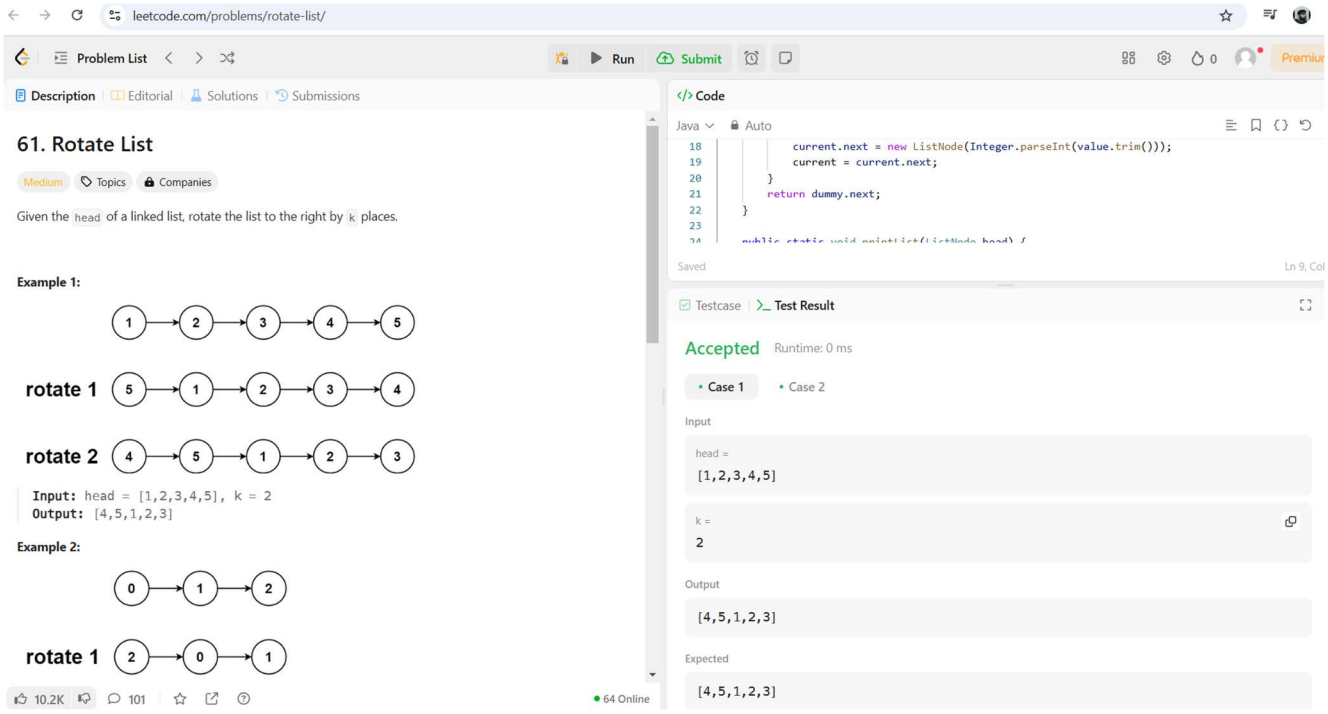
3.Code:

```
class ListNode {

int val;

ListNode next;

ListNode(int val) {

this.val = val;

this.next = null;

}

public static ListNode deserialize(String data) {

if (data == null || data.isEmpty() || data.equals("[]")) return null;

String[] values = data.replace("[", "").replace("]", "").split(",");

ListNode dummy = new ListNode(0);

ListNode current = dummy;

for (String value : values) {

current.next = new ListNode(Integer.parseInt(value.trim()));

current = current.next;
```

```
}
return dummy.next;
}
public static void printList(ListNode head) {
while (head != null) {
System.out.print(head.val + " -> ");
head = head.next;
}
System.out.println("null");
}
}
public class Solution {
public ListNode rotateRight(ListNode head, int k) {
if (head == null || head.next == null || k == 0) return head;
int length = 1;
ListNode tail = head;
while (tail.next != null) {
tail = tail.next;
length++;
}
k = k % length;
if (k == 0) return head; // No change needed
ListNode prev = head;
for (int i = 1; i < length - k; i++) {
```

```
prev = prev.next;
}
ListNode newHead = prev.next;
prev.next = null;
tail.next = head; // Connect old tail to old head
return newHead;
}
public static void main(String[] args) {
String input = "[1,2,3,4,5]";
int k = 2;
ListNode head = ListNode.deserialize(input);
System.out.println("Original List:");
ListNode.printList(head);
Solution solution = new Solution();
head = solution.rotateRight(head, k);
System.out.println("Rotated List:");
ListNode.printList(head);
}
}
```

4.Output:



5.Learning Outcomes:

- Understand the concept and implementation of rotating a singly linked list.
- Develop skills in optimizing operations by handling edge cases efficiently.
- Practice in-place modifications, including updating pointers for rotation.
- Enhance debugging abilities by testing various input scenarios.

Problem 4

1.Aim:

To implement an efficient algorithm that merges k sorted linked lists into a single sorted linked list using priority queues or divide-and-conquer techniques.

2.Objective:

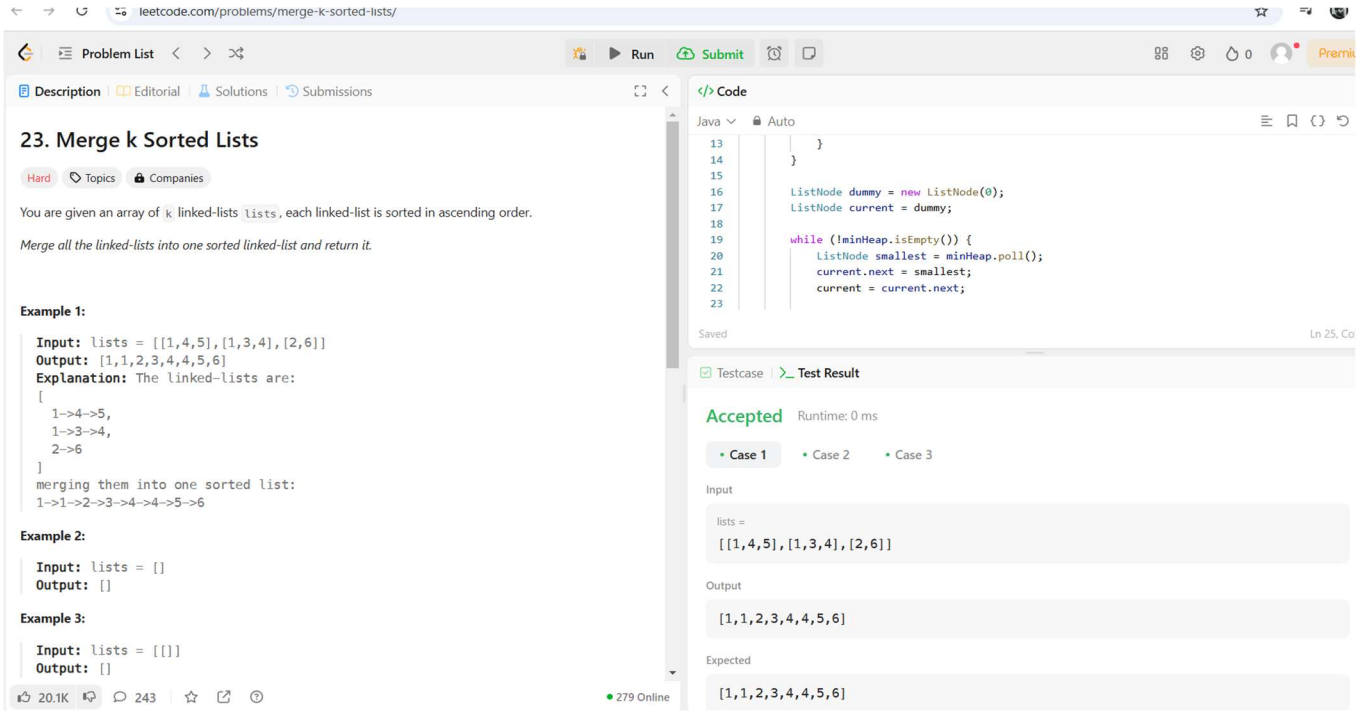
- Understand the concept of merging multiple sorted linked lists into a single sorted list.
- Explore and implement various approaches to solve the problem, including:
- Utilizing a min-heap (priority queue) for efficient merging.
- Applying a divide-and-conquer strategy to iteratively merge pairs of lists.

3.Code:

```
import java.util.PriorityQueue;
public class Solution {
public ListNode mergeKLists(ListNode[] lists) {
if (lists == null || lists.length == 0) return null;
PriorityQueue<ListNode> minHeap = new PriorityQueue<>((a, b) -> a.val - b.val);
for (ListNode list : lists) {
if (list != null) {
minHeap.offer(list);
}
}
ListNode dummy = new ListNode(0);
ListNode current = dummy;
while (!minHeap.isEmpty()) {
ListNode smallest = minHeap.poll();
current.next = smallest;
current = current.next;
if (smallest.next != null) {
minHeap.offer(smallest.next);
```

```
}
}
return dummy.next;
}
}
```

4.Output:



5.Learning Outcomes:

- Understand how to merge multiple sorted linked lists into a single sorted list.
- Learn to implement efficient merging using a min-heap (priority queue).
- Explore the divide-and-conquer approach for merging lists.
- Analyze and compare different merging strategies based on time and space complexity.

Problem 5

1.Aim:

To develop an algorithm for sorting a singly linked list in ascending order using efficient techniques such as merge sort or quick sort.

2.Objective:

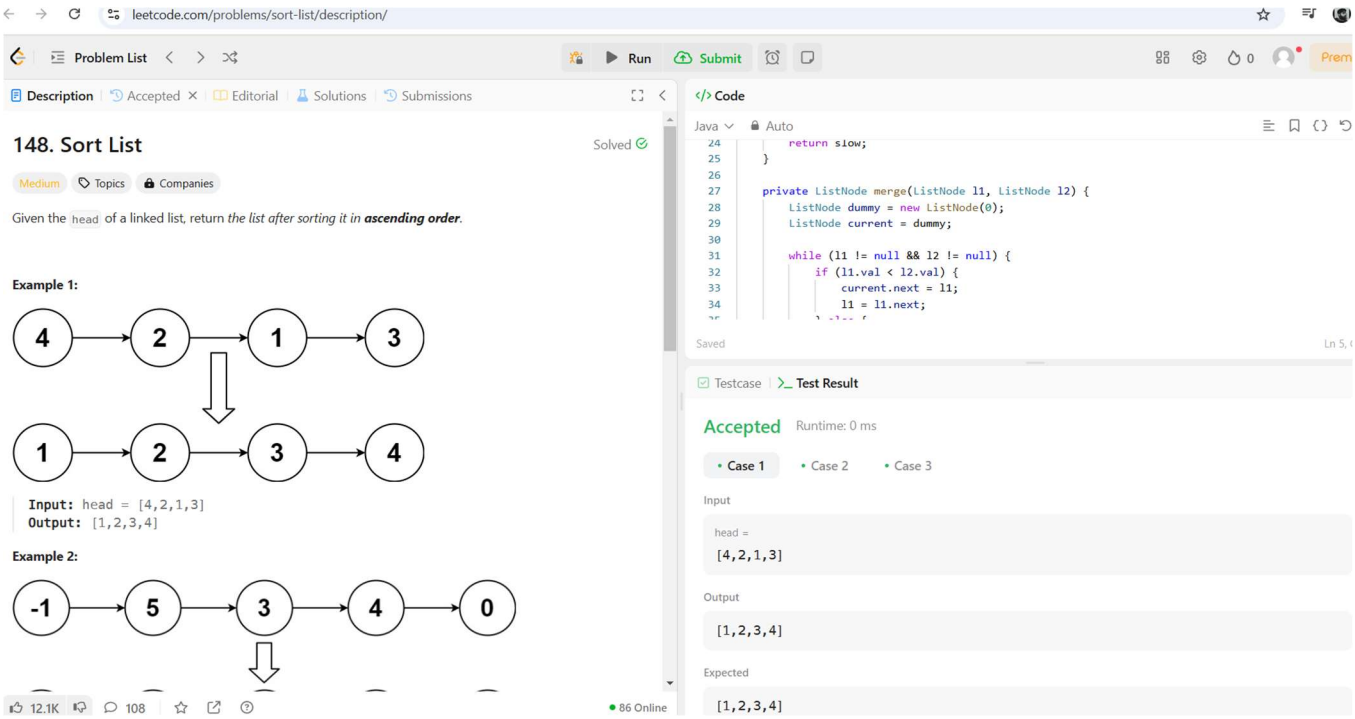
- Understand and implement efficient sorting techniques for singly linked lists.
- Explore merge sort and quick sort for linked list sorting.
- Analyze the time and space complexity of different sorting approaches.
- Develop skills in manipulating linked lists for in-place sorting.

3.Code:

```
public class Solution {
public ListNode sortList(ListNode head) {
if (head == null || head.next == null) return head;

ListNode mid = getMiddle(head);
ListNode left = head;
ListNode right = mid.next;
mid.next = null; // Break the list

left = sortList(left);
right = sortList(right);

return merge(left, right);
}
private ListNode getMiddle(ListNode head) {
ListNode slow = head, fast = head.next;
while (fast != null && fast.next != null) {
slow = slow.next;
```

```
fast = fast.next.next;
}
return slow;
}
private ListNode merge(ListNode l1, ListNode l2) {
ListNode dummy = new ListNode(0);
ListNode current = dummy;

while (l1 != null && l2 != null) {
if (l1.val < l2.val) {
current.next = l1;
l1 = l1.next;
} else {

current.next = l2;
l2 = l2.next;
}
current = current.next;
}

if (l1 != null) current.next = l1;
if (l2 != null) current.next = l2;

return dummy.next;
}

}
```

4.Output:



5.Learning Outcomes:

- Gain proficiency in sorting a singly linked list using efficient algorithms.
- Understand the working principles of merge sort and quick sort for linked lists.
- Learn to optimize sorting operations while considering time and space complexity.
- Develop problem-solving skills for handling linked list-based sorting challenges.