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DSA LAB REPORT

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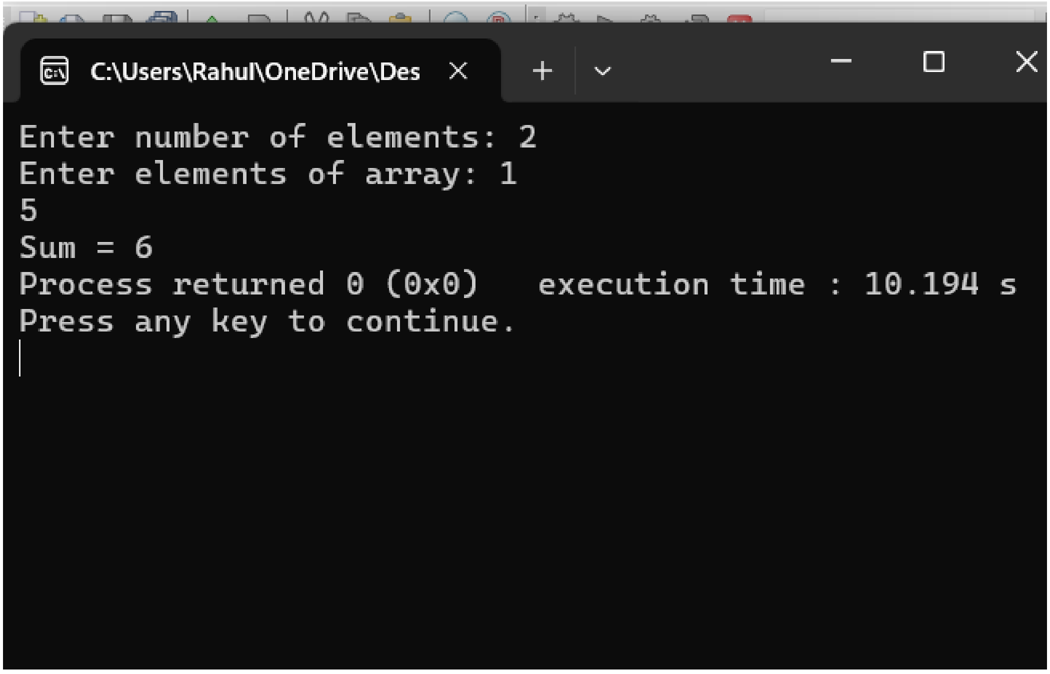
Lab No	Date	Topic
Lab 1	31-01-25	Arrays
Lab 2	07-02-25	Linked List
Lab 3	14-02-25	Doubly Linked List
Lab 4	21-02-25	Circular Linked List
Lab 5	28-02-25	Reverse Codes
Lab 6	07-03-25	Stack Operations
Lab 7	12-03-25	Queues
Lab 8	28-03-25	Priority Queues
Lab 9	04-04-25	Trees
Lab10	11-04-25	Binary Search Tree
Lab11	25-04-25	AVL

LAB-1(31-01-25)

1.Malloc

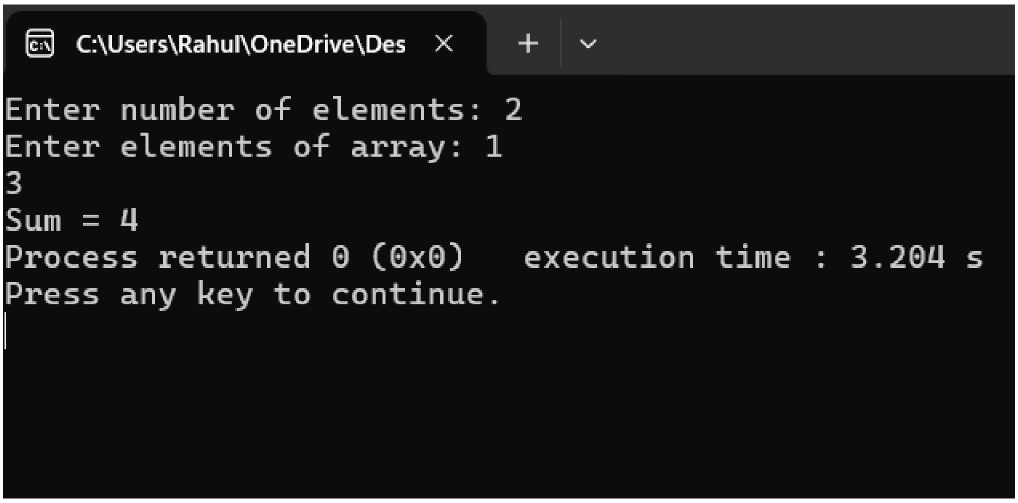
```
#include <stdio.h>
#include <stdlib.h>
int main() {
int n, i, *ptr, sum = 0;
printf("Enter number of elements: ");
scanf("%d", &n);
ptr = (int*)malloc(n * sizeof(int));
if (ptr == NULL) {
printf("Error! Memory not allocated.");
exit(0);
}
printf("Enter elements of array: ");
for (i = 0; i < n; ++i) {
scanf("%d", ptr + i);
sum += *(ptr + i);
}

printf("Sum = %d", sum);

free(ptr);

return 0;

}
```



```
Enter number of elements: 2
Enter elements of array: 1
5
Sum = 6
Process returned 0 (0x0)   execution time : 10.194 s
Press any key to continue.
```

2.Calloc

```
#include <stdio.h>

#include <stdlib.h>

int main() {

int n, i, *ptr, sum = 0;
printf("Enter number of elements: ");

scanf("%d", &n);

ptr = (int*)calloc(n, sizeof(int));

if (ptr == NULL) {

printf("Error! Memory not allocated.");

exit(0);

}

printf("Enter elements of array: ");

for (i = 0; i < n; ++i) {

scanf("%d", ptr + i);

sum += *(ptr + i);

}

printf("Sum = %d", sum);

free(ptr);

return 0;

}
```



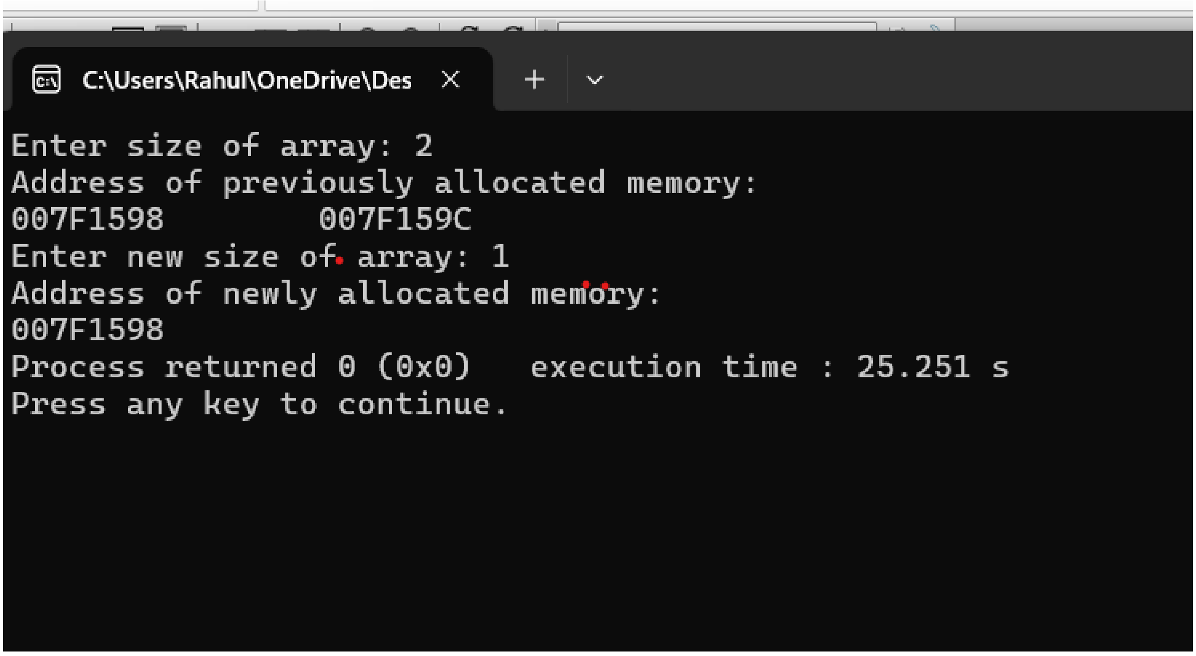
```
Enter number of elements: 2
Enter elements of array: 1
3
Sum = 4
Process returned 0 (0x0)   execution time : 3.204 s
Press any key to continue.
```

3.Realloc

```
#include <stdio.h>

#include <stdlib.h>

int main() {

int *ptr, i, n1, n2;

printf("Enter size of array: ");

scanf("%d", &n1);

ptr = (int*)malloc(n1 * sizeof(int));

printf("Address of previously allocated memory:\n");

for (i = 0; i < n1; ++i) {

printf("%p\t", (ptr + i));

}

printf("\nEnter new size of array: ");

scanf("%d", &n2);

ptr = realloc(ptr, n2 * sizeof(int));

printf("Address of newly allocated memory:\n");

for (i = 0; i < n2; ++i) {

printf("%p\t", (ptr + i));

}

free(ptr);
```

return 0;

}

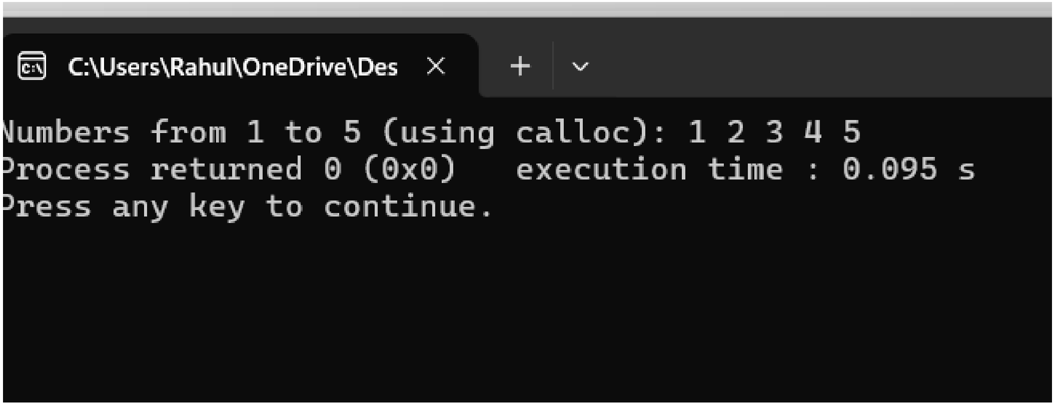


```
Enter size of array: 2
Address of previously allocated memory:
007F1598        007F159C
Enter new size of array: 1
Address of newly allocated memory:
007F1598
Process returned 0 (0x0)   execution time : 25.251 s
Press any key to continue.
```

4. Calloc to print 1 to 5 nuimbers

```
#include <stdio.h>

#include <stdlib.h>

int main() {

int *ptr, i;

ptr = (int*)calloc(5, sizeof(int));

if (ptr == NULL) {

printf("Error! Memory not allocated.");

exit(0);

}

for (i = 0; i < 5; i++) {
```

```
ptr[i] = i + 1;

}

printf("Numbers from 1 to 5 (using calloc): ");

for (i = 0; i < 5; i++) {

printf("%d ", ptr[i]);

}

free(ptr);

return 0;

}
```

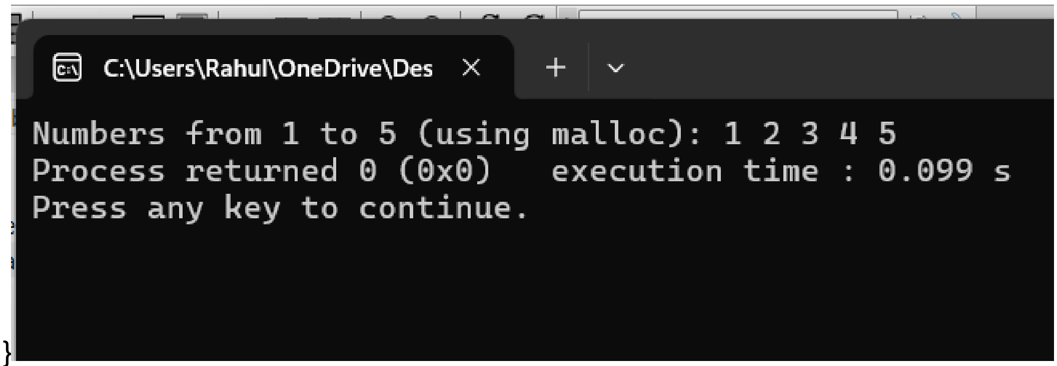


```
Numbers from 1 to 5 (using calloc): 1 2 3 4 5
Process returned 0 (0x0)   execution time : 0.095 s
Press any key to continue.
```

5.Malloc to print 1to 5 numbers

```
#include <stdio.h>

#include <stdlib.h>

int main() {

int *ptr, i;
```

```
ptr = (int*)malloc(5 * sizeof(int));

if (ptr == NULL) {

printf("Error! Memory not allocated.");

exit(0);

}

for (i = 0; i < 5; i++) {

ptr[i] = i + 1;

}

printf("Numbers from 1 to 5 (using malloc): ");

for (i = 0; i < 5; i++) {

printf("%d ", ptr[i]);

}

free(ptr);

return 0;
```



```
Numbers from 1 to 5 (using malloc): 1 2 3 4 5
Process returned 0 (0x0)   execution time : 0.099 s
Press any key to continue.
```

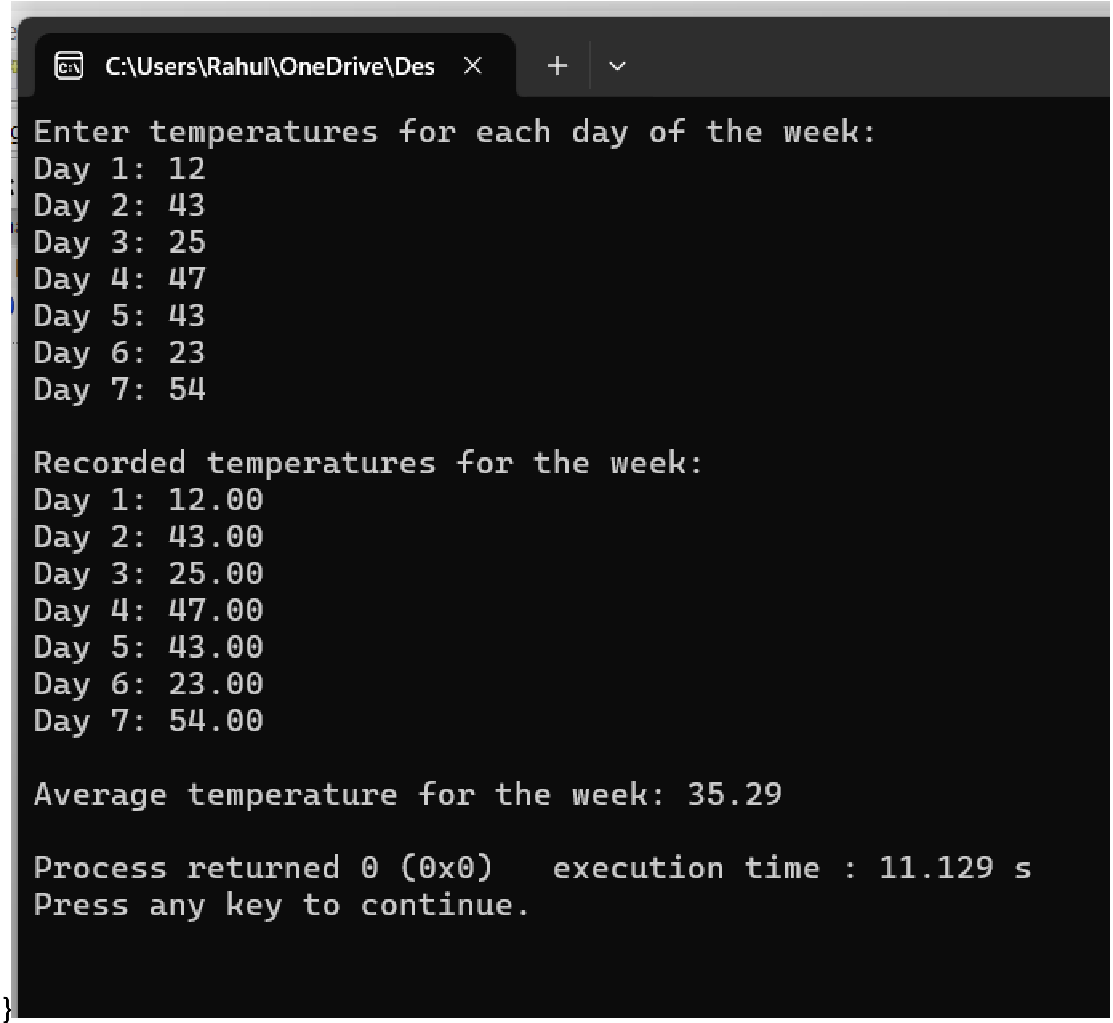
```
}
```

6. Real World scenarios involving array

```
#include <stdio.h>

#define DAYS_IN_WEEK 7

int main() {
// Declare an array to store temperatures for each day of the week
float temperatures[DAYS_IN_WEEK];

// Input temperatures for each day
printf("Enter temperatures for each day of the week:\n");
for (int i = 0; i < DAYS_IN_WEEK; ++i) {
printf("Day %d: ", i + 1);
scanf("%f", &temperatures[i]);
}

// Display the recorded temperatures
printf("\nRecorded temperatures for the week:\n");
for (int i = 0; i < DAYS_IN_WEEK; ++i) {
printf("Day %d: %.2f\n", i + 1, temperatures[i]);
}

// Calculate and display the average temperature
float totalTemperature = 0;
for (int i = 0; i < DAYS_IN_WEEK; ++i) {
totalTemperature += temperatures[i];
}

float averageTemperature = totalTemperature / DAYS_IN_WEEK;
```

printf("\nAverage temperature for the week: %.2f\n", averageTemperature);

return 0;

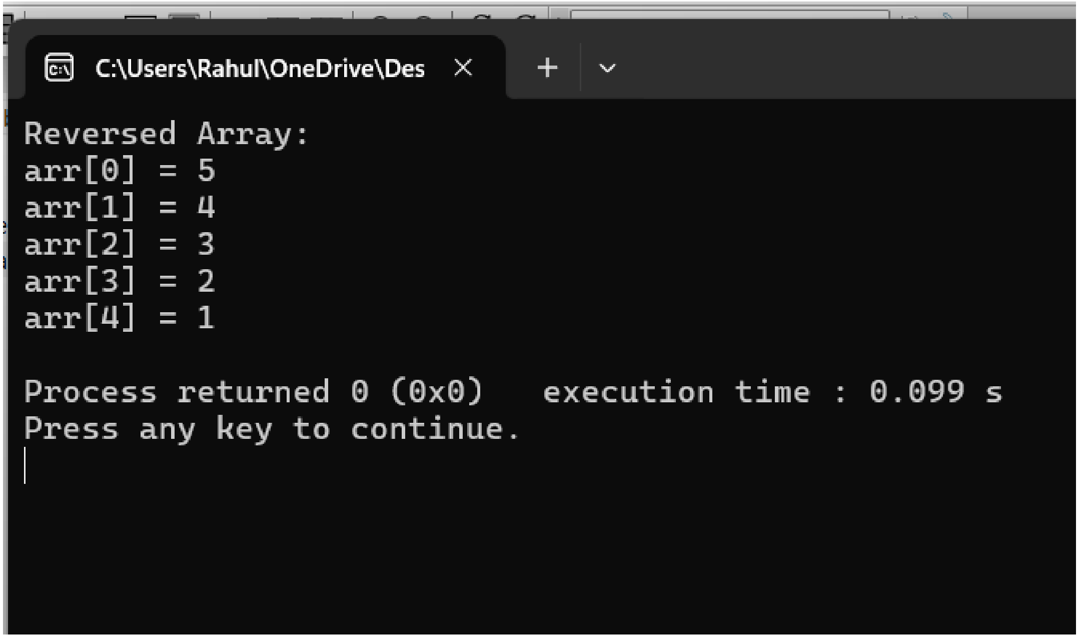


```
Enter temperatures for each day of the week:
Day 1: 12
Day 2: 43
Day 3: 25
Day 4: 47
Day 5: 43
Day 6: 23
Day 7: 54

Recorded temperatures for the week:
Day 1: 12.00
Day 2: 43.00
Day 3: 25.00
Day 4: 47.00
Day 5: 43.00
Day 6: 23.00
Day 7: 54.00

Average temperature for the week: 35.29

Process returned 0 (0x0)   execution time : 11.129 s
Press any key to continue.
```

}

7. Reverse an array

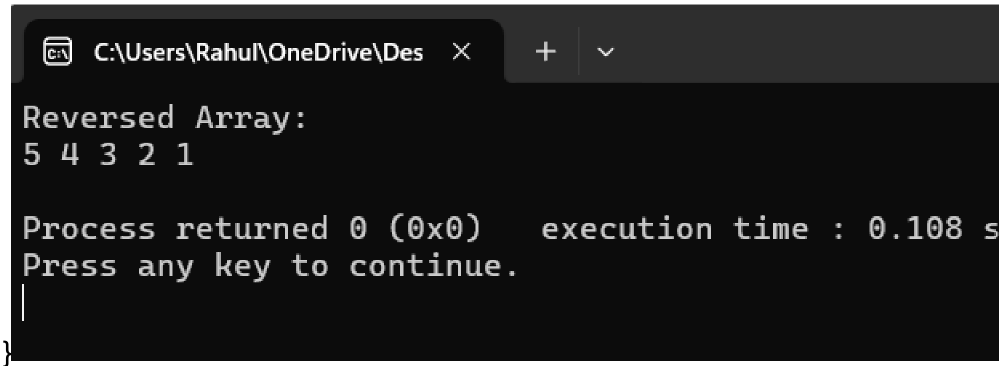
```
#include <stdio.h>
int main() {
int n = 5; // Size of the array
int rev[5]; // Array to store the reversed elements
int arr[5] = {1, 2, 3, 4, 5}; // Original array

// Reverse the array
for (int i = 0; i < n; i++) {
rev[i] = arr[n - i - 1];
}

// Print the reversed array
printf("Reversed Array:\n");
for (int i = 0; i < n; i++) {

printf("arr[%d] = %d\n", i, rev[i]);

}


return 0;

}
```



```
Reversed Array:
arr[0] = 5
arr[1] = 4
arr[2] = 3
arr[3] = 2
arr[4] = 1

Process returned 0 (0x0)   execution time : 0.099 s
Press any key to continue.
```

8. Another logic for Reversing array

```
#include <stdio.h>

int main() {

int arr[5] = {1, 2, 3, 4, 5};
int n = 5;


printf("Reversed Array:\n");

for (int i = n - 1; i >= 0; i--) {

printf("%d ", arr[i]);

}


printf("\n");

return 0;
```

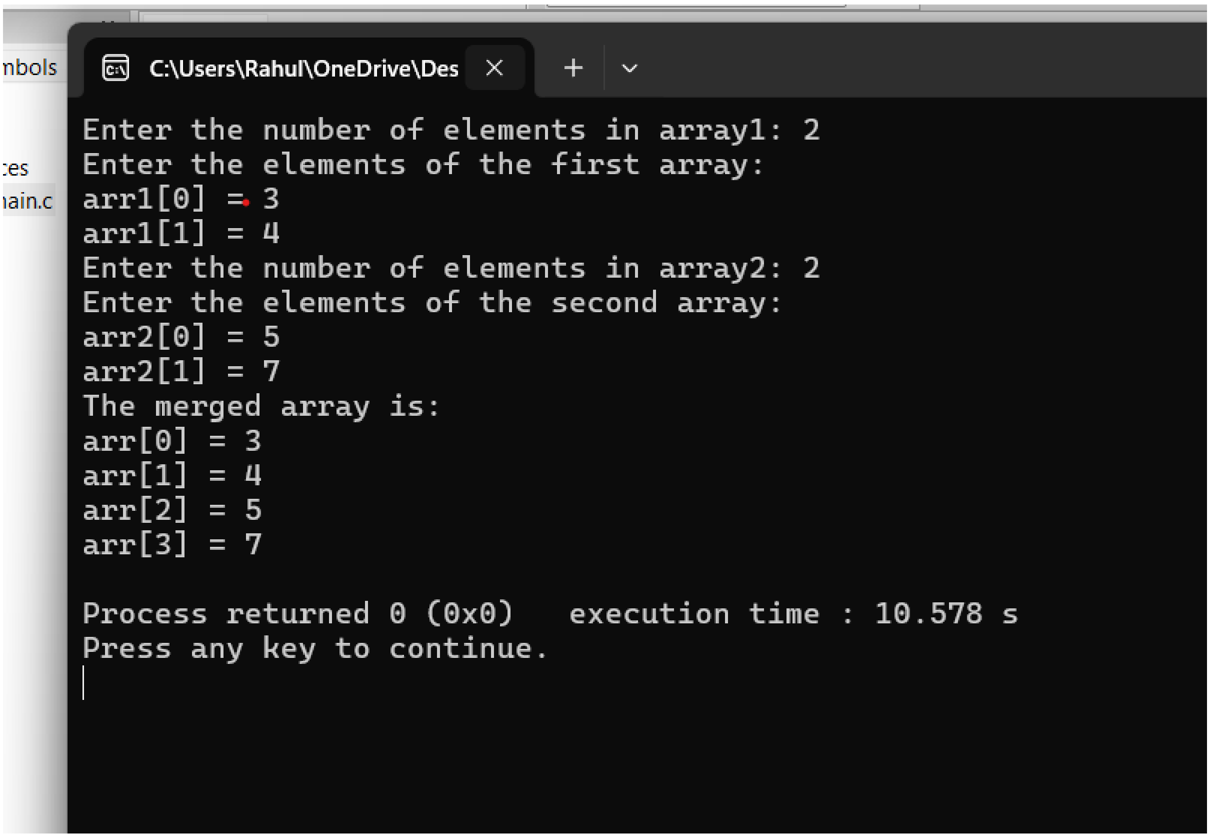


```
Reversed Array:
5 4 3 2 1

Process returned 0 (0x0)   execution time : 0.108 s
Press any key to continue.
```

```
}
```

9. Merge 2 arrays

```
include <stdio.h>

int main() {
int arr1[10], arr2[10], arr3[20];
int i, n1, n2, m, index = 0;

// Input size and elements of the first array
printf("Enter the number of elements in array1: ");
scanf("%d", &n1);
printf("Enter the elements of the first array:\n");
for (i = 0; i < n1; i++) {
printf("arr1[%d] = ", i);
scanf("%d", &arr1[i]);
}

// Input size and elements of the second array
printf("Enter the number of elements in array2: ");
scanf("%d", &n2);
printf("Enter the elements of the second array:\n");
for (i = 0; i < n2; i++) {
printf("arr2[%d] = ", i);
scanf("%d", &arr2[i]);
}

// Merge the first array into the third array
for (i = 0; i < n1; i++) {
arr3[index++] = arr1[i];
}

// Merge the second array into the third array
for (i = 0; i < n2; i++) {
arr3[index++] = arr2[i];
}

// Print the merged array
m = n1 + n2;
printf("The merged array is:\n");
for (i = 0; i < m; i++) {
printf("arr[%d] = %d\n", i, arr3[i]);
}

return 0;
}
```



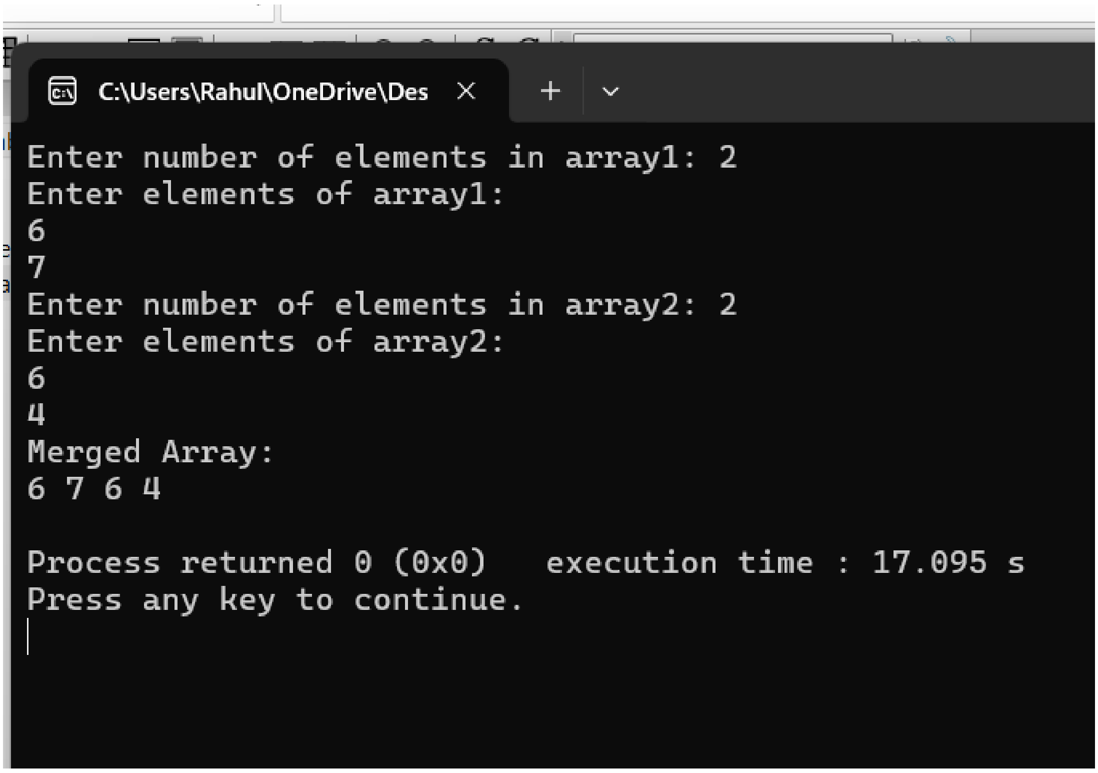
```
Enter the number of elements in array1: 2
Enter the elements of the first array:
arr1[0] = 3
arr1[1] = 4
Enter the number of elements in array2: 2
Enter the elements of the second array:
arr2[0] = 5
arr2[1] = 7
The merged array is:
arr[0] = 3
arr[1] = 4
arr[2] = 5
arr[3] = 7

Process returned 0 (0x0)   execution time : 10.578 s
Press any key to continue.
```

10. Another logic

```
#include <stdio.h>


int main() {
```

```
int arr1[10], arr2[10], arr3[20];
int n1, n2, i;

// Input size and elements of the first array
printf("Enter number of elements in array1: ");
scanf("%d", &n1);
printf("Enter elements of array1:\n");
for (i = 0; i < n1; i++) {
scanf("%d", &arr1[i]);
}

// Input size and elements of the second array
printf("Enter number of elements in array2: ");
scanf("%d", &n2);
printf("Enter elements of array2:\n");
for (i = 0; i < n2; i++) {
scanf("%d", &arr2[i]);
}

// Merge the arrays
for (i = 0; i < n1; i++) {
arr3[i] = arr1[i];
}
for (i = 0; i < n2; i++) {
arr3[n1 + i] = arr2[i];
}

// Print the merged array
```

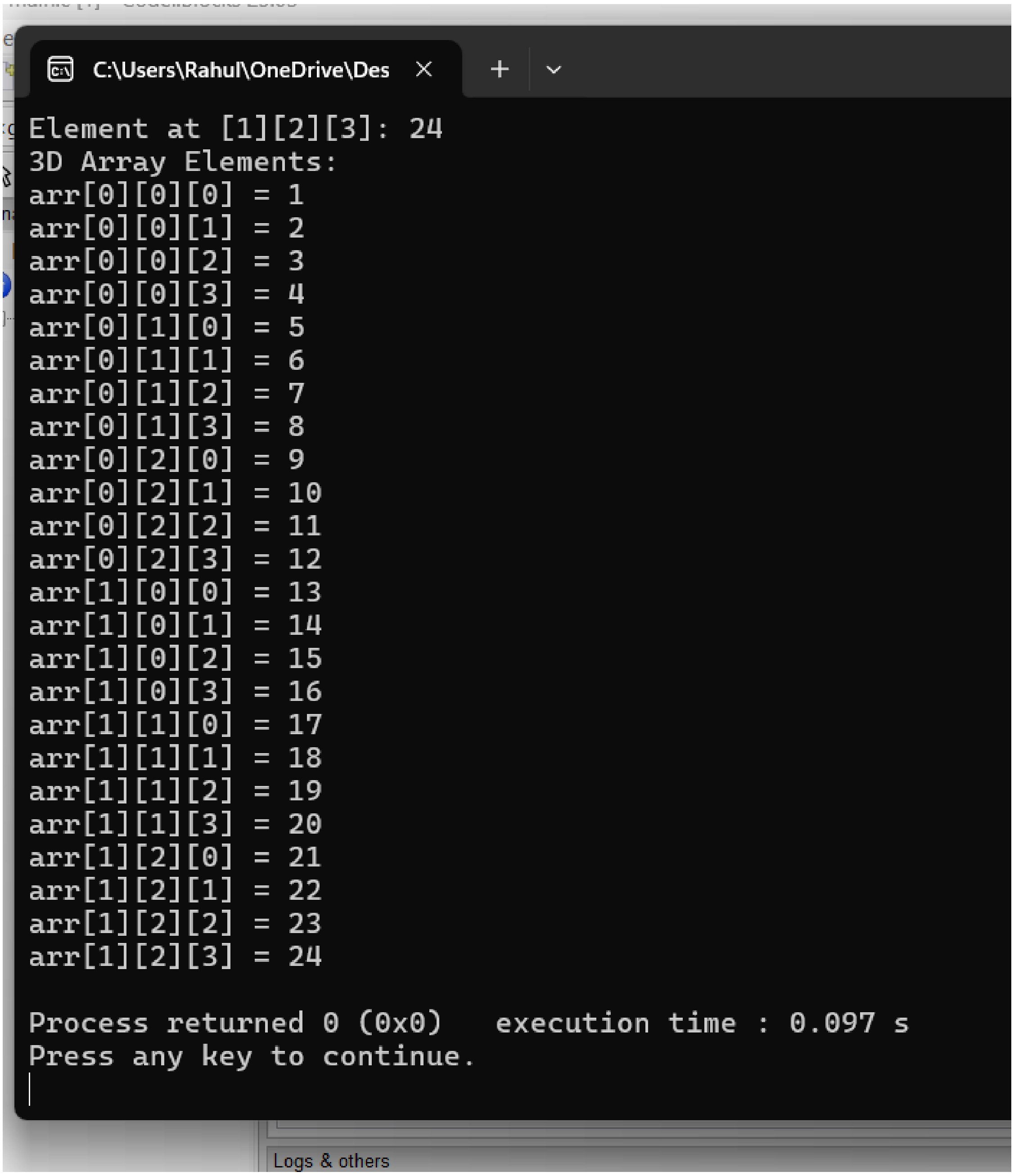
```
printf("Merged Array:\n");

for (i = 0; i < n1 + n2; i++) {

printf("%d ", arr3[i]);

}


printf("\n");

return 0;

}
```



```
Enter number of elements in array1: 2
Enter elements of array1:
6
7
Enter number of elements in array2: 2
Enter elements of array2:
6
4
Merged Array:
6 7 6 4

Process returned 0 (0x0)   execution time : 17.095 s
Press any key to continue.
```

11. Array 3d

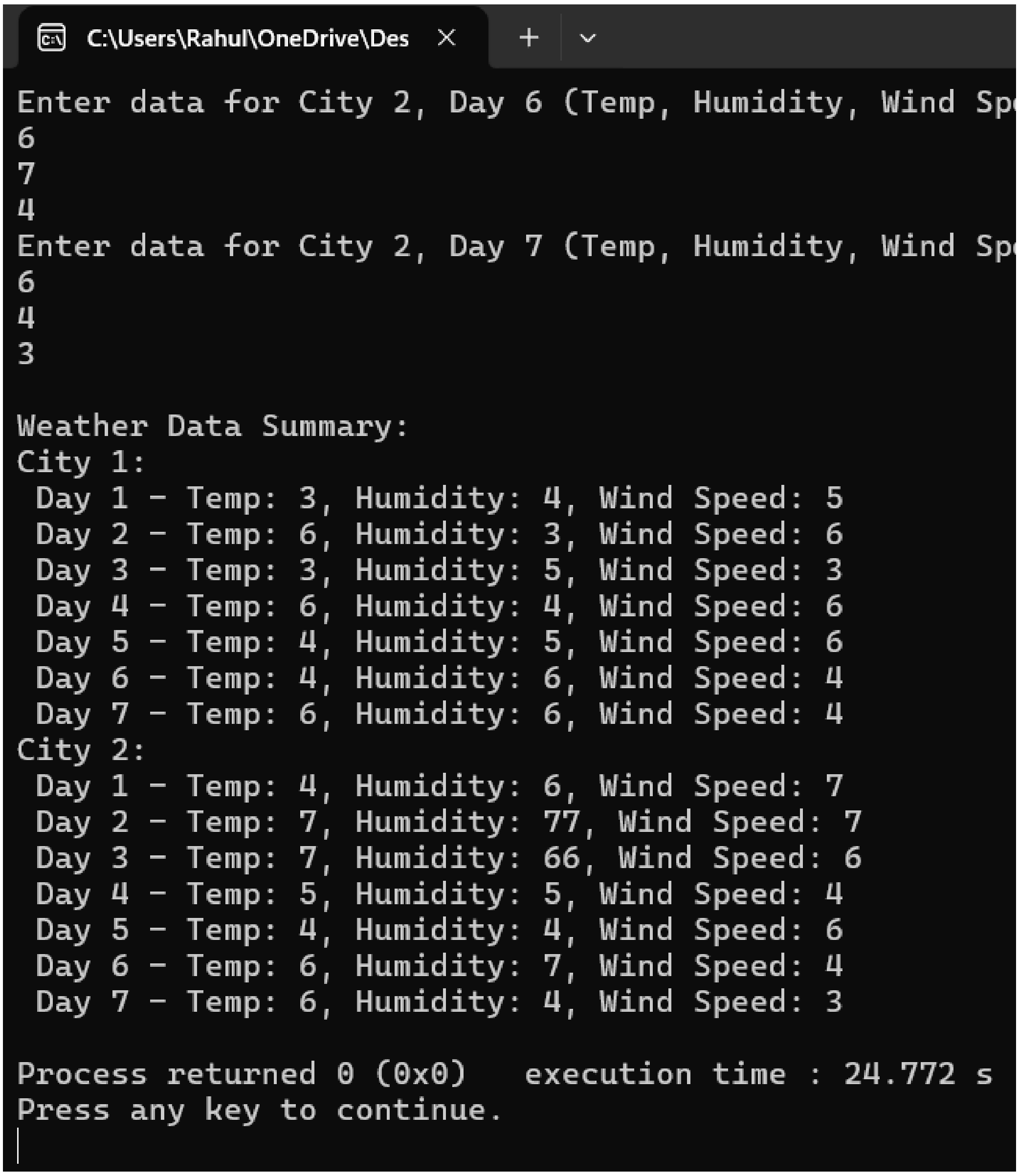
```
#include <stdio.h>

int main() {
// Define a 3D array with dimensions 2x3x4
// It contains 2 layers, each with 3 rows and 4 columns
int arr[2][3][4] = {
{
{1, 2, 3, 4}, // First row of first layer
{5, 6, 7, 8}, // Second row of first layer
{9, 10, 11, 12} // Third row of first layer
},
{
{13, 14, 15, 16}, // First row of second layer
{17, 18, 19, 20}, // Second row of second layer
{21, 22, 23, 24} // Third row of second layer
}
};
// Access a specific element in the 3D array
printf("Element at [1][2][3]: %d\n", arr[1][2][3]); // This prints 24

// Print all elements in the 3D array
printf("3D Array Elements:\n");
for (int i = 0; i < 2; i++) { // Loop through each layer
for (int j = 0; j < 3; j++) { // Loop through each row
for (int k = 0; k < 4; k++) { // Loop through each column
printf("arr[%d][%d][%d] = %d\n", i, j, k, arr[i][j][k]);
}
}
}

return 0;
}
```



```
Element at [1][2][3]: 24
3D Array Elements:
arr[0][0][0] = 1
arr[0][0][1] = 2
arr[0][0][2] = 3
arr[0][0][3] = 4
arr[0][1][0] = 5
arr[0][1][1] = 6
arr[0][1][2] = 7
arr[0][1][3] = 8
arr[0][2][0] = 9
arr[0][2][1] = 10
arr[0][2][2] = 11
arr[0][2][3] = 12
arr[1][0][0] = 13
arr[1][0][1] = 14
arr[1][0][2] = 15
arr[1][0][3] = 16
arr[1][1][0] = 17
arr[1][1][1] = 18
arr[1][1][2] = 19
arr[1][1][3] = 20
arr[1][2][0] = 21
arr[1][2][1] = 22
arr[1][2][2] = 23
arr[1][2][3] = 24

Process returned 0 (0x0)   execution time : 0.097 s
Press any key to continue.
```

12. Weather data management

```
#include <stdio.h>


int main() {
// 3D array to store weather data
// Dimensions: 2 cities, 7 days, 3 parameters (temperature, humidity, wind speed)
int weather[2][7][3];


// Input weather data for each city and day
for (int city = 0; city < 2; city++) {
for (int day = 0; day < 7; day++) {
printf("Enter data for City %d, Day %d (Temp, Humidity, Wind Speed):\n", city + 1, day + 1);
for (int parameter = 0; parameter < 3; parameter++) {
scanf("%d", &weather[city][day][parameter]);
}
}
}

// Display the collected weather data
printf("\nWeather Data Summary:\n");
for (int city = 0; city < 2; city++) {
printf("City %d:\n", city + 1);
for (int day = 0; day < 7; day++) {
printf(" Day %d - Temp: %d, Humidity: %d, Wind Speed: %d\n",
day + 1,
weather[city][day][0],
weather[city][day][1],
weather[city][day][2]);
}
}

return 0;
}
```



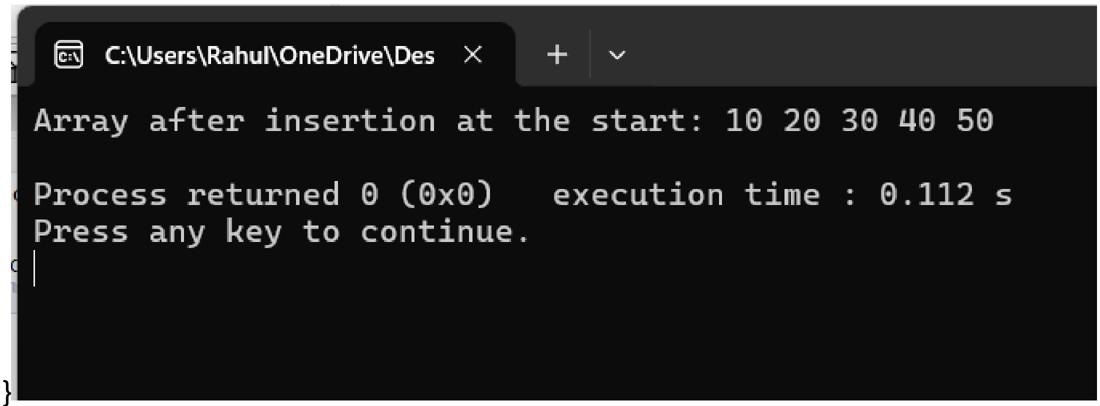
```
Enter data for City 2, Day 6 (Temp, Humidity, Wind Sp
6
7
4
Enter data for City 2, Day 7 (Temp, Humidity, Wind Sp
6
4
3

Weather Data Summary:
City 1:
 Day 1 - Temp: 3, Humidity: 4, Wind Speed: 5
 Day 2 - Temp: 6, Humidity: 3, Wind Speed: 6
 Day 3 - Temp: 3, Humidity: 5, Wind Speed: 3
 Day 4 - Temp: 6, Humidity: 4, Wind Speed: 6
 Day 5 - Temp: 4, Humidity: 5, Wind Speed: 6
 Day 6 - Temp: 4, Humidity: 6, Wind Speed: 4
 Day 7 - Temp: 6, Humidity: 6, Wind Speed: 4
City 2:
 Day 1 - Temp: 4, Humidity: 6, Wind Speed: 7
 Day 2 - Temp: 7, Humidity: 77, Wind Speed: 7
 Day 3 - Temp: 7, Humidity: 66, Wind Speed: 6
 Day 4 - Temp: 5, Humidity: 5, Wind Speed: 4
 Day 5 - Temp: 4, Humidity: 4, Wind Speed: 6
 Day 6 - Temp: 6, Humidity: 7, Wind Speed: 4
 Day 7 - Temp: 6, Humidity: 4, Wind Speed: 3

Process returned 0 (0x0)   execution time : 24.772 s
Press any key to continue.
```

13. Insertion in an array

INSERT AT START

```
#include <stdio.h>

// Function to insert an element at the start of the array
int insertAtStart(int arr[], int n, int value) {
// Shift all elements to the right to make space at the start
for (int i = n; i > 0; i--) {
arr[i] = arr[i - 1];
}
// Place the new value at the start
arr[0] = value;

// Return the updated size of the array
return n + 1;
}

int main() {
int arr[10] = {20, 30, 40, 50}; // Array with initial elements
int n = 4; // Current size of the array
int value = 10; // Value to insert at the start

// Insert at the start
n = insertAtStart(arr, n, value);

// Display the updated array
printf("Array after insertion at the start: ");
for (int i = 0; i < n; i++) {
```

```
printf("%d ", arr[i]);

}

printf("\n");


return 0;
```

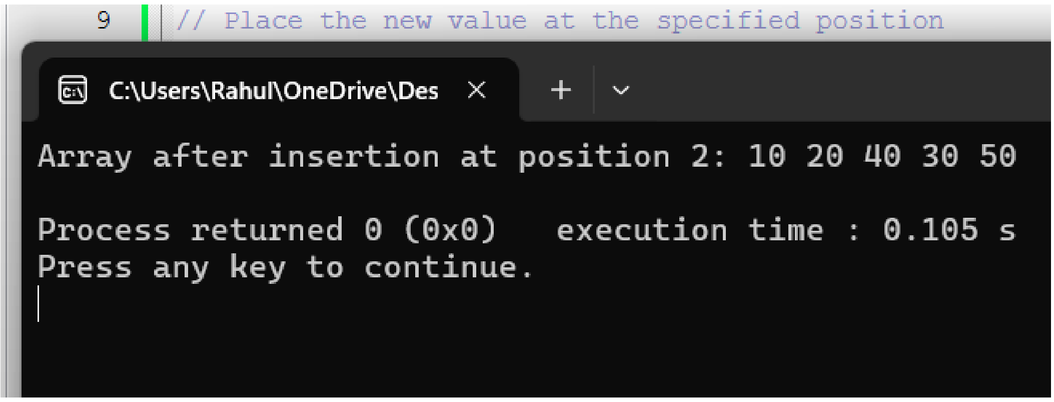


```
Array after insertion at the start: 10 20 30 40 50

Process returned 0 (0x0)   execution time : 0.112 s
Press any key to continue.
```

```
}
```

14. insert at specific position

```
#include <stdio.h>

// Function to insert an element at a specific position
int insertAtPosition(int arr[], int n, int pos, int value) {
// Shift elements to the right starting from the end up to position
for (int i = n; i > pos; i--) {
arr[i] = arr[i - 1];
}
// Place the new value at the specified position
arr[pos] = value;

// Return the updated size of the array
return n + 1;
}

int main() {
int arr[10] = {10, 20, 30, 50}; // Array with initial elements
int n = 4; // Current size of the array
int pos = 2; // Position to insert (0-based index)
int value = 40; // Value to insert at the position

// Insert at specified position
n = insertAtPosition(arr, n, pos, value);

// Display the updated array
printf("Array after insertion at position %d: ", pos);
for (int i = 0; i < n; i++) {

printf("%d ", arr[i]);

}

printf("\n");


return 0;

}
```

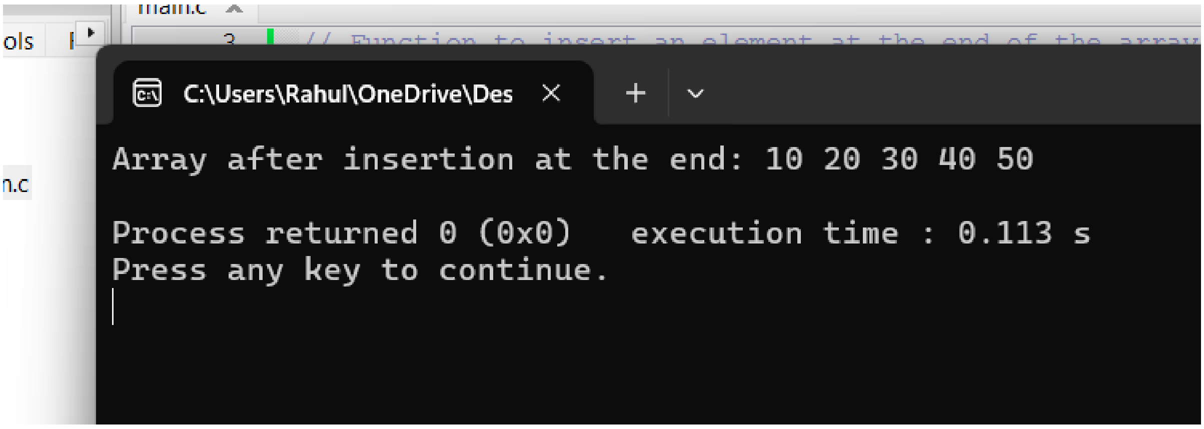


```
// Place the new value at the specified position
```

```
Array after insertion at position 2: 10 20 40 30 50

Process returned 0 (0x0)   execution time : 0.105 s
Press any key to continue.
```

15. Insert at END

```
#include <stdio.h>

// Function to insert an element at the end of the array
int insertAtEnd(int arr[], int n, int value) {
// Place the new value at the end
arr[n] = value;

// Return the updated size of the array
return n + 1;
}

int main() {
int arr[10] = {10, 20, 30, 40}; // Array with initial elements
int n = 4; // Current size of the array
int value = 50; // Value to insert at the end

// Insert at the end
n = insertAtEnd(arr, n, value);

// Display the updated array
printf("Array after insertion at the end: ");
for (int i = 0; i < n; i++) {
printf("%d ", arr[i]);
}
printf("\n");
return 0;

}
```

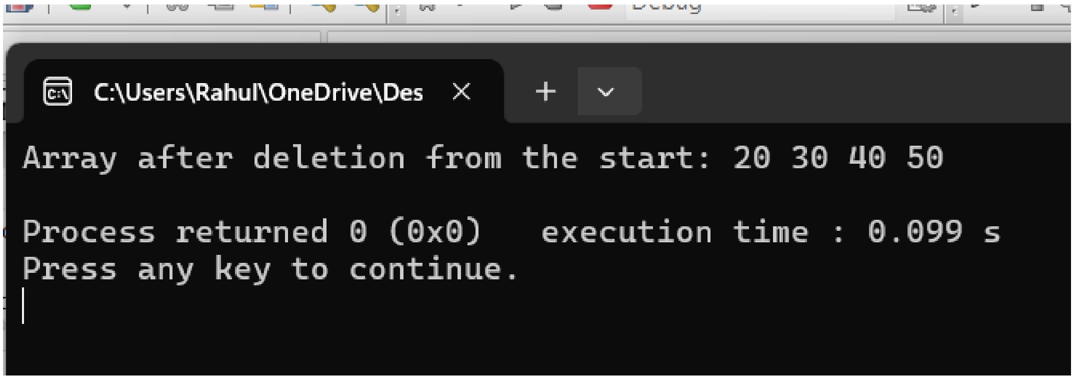

main.c
ols
n.c
// Function to insert an element at the end of the array
C:\Users\Rahul\OneDrive\Des

```
Array after insertion at the end: 10 20 30 40 50

Process returned 0 (0x0)   execution time : 0.113 s
Press any key to continue.
```

16. DELETION FROM AN ARRAY

DELETE FROM START

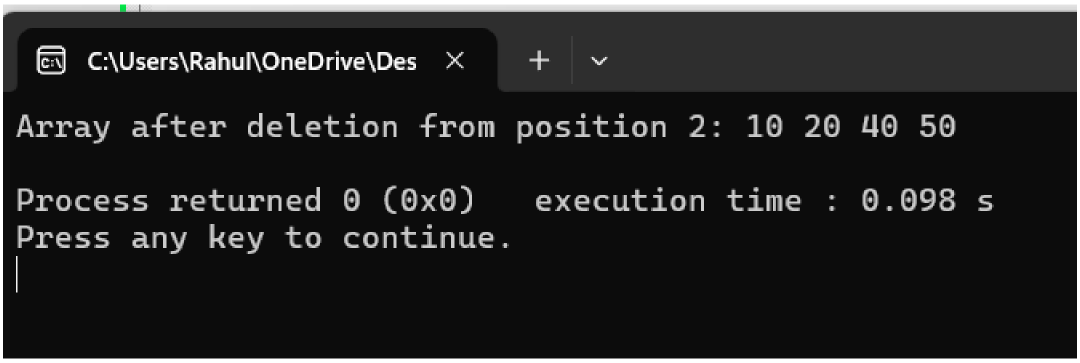
```
#include <stdio.h>


// Function to delete the first element from the array
int deleteFromStart(int arr[], int n) {
// Shift elements to the left to overwrite the first element
for (int i = 0; i < n - 1; i++) {
arr[i] = arr[i + 1];
}
// Return the updated size of the array
return n - 1;
}


int main() {
int arr[10] = {10, 20, 30, 40, 50}; // Initial elements
int n = 5; // Size of array


// Delete the first element
n = deleteFromStart(arr, n);


// Print updated array
printf("Array after deletion from the start: ");
for (int i = 0; i < n; i++) {
printf("%d ", arr[i]);
}
printf("\n");
return 0;

}
```



```
Array after deletion from the start: 20 30 40 50

Process returned 0 (0x0)   execution time : 0.099 s
Press any key to continue.
```

17. Delete from specific position

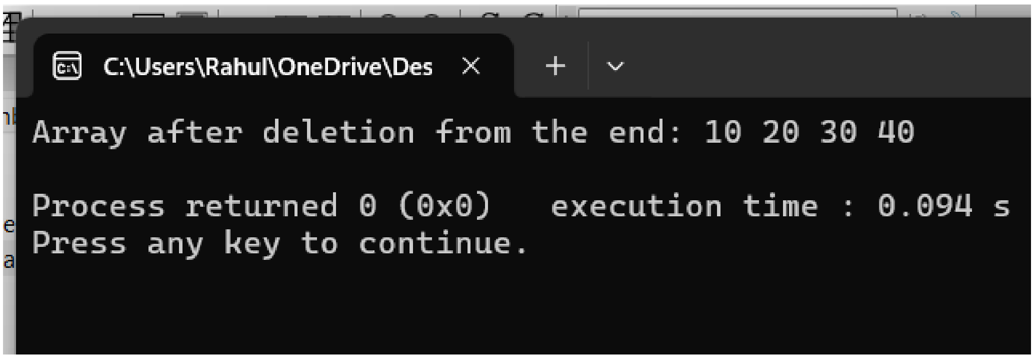
```
#include <stdio.h>

// Function to delete an element from a specific position
int deleteFromPosition(int arr[], int n, int pos) {
// Check for invalid position
if (pos < 0 || pos >= n) {
printf("Invalid position!\n");
return n;
}

// Shift elements to the left from the position
for (int i = pos; i < n - 1; i++) {
arr[i] = arr[i + 1];
}

// Return the updated size
return n - 1;
}

int main() {
int arr[10] = {10, 20, 30, 40, 50}; // Initial array
int n = 5; // Size
int pos = 2; // Index to delete (0-based)

// Delete from specified position
n = deleteFromPosition(arr, n, pos);
// Print updated array

printf("Array after deletion from position %d: ", pos);

for (int i = 0; i < n; i++) {

printf("%d ", arr[i]);

}

printf("\n");


return 0;

}
```



```
Array after deletion from position 2: 10 20 40 50

Process returned 0 (0x0)   execution time : 0.098 s
Press any key to continue.
```

18.Delete from the END

```
#include <stdio.h>

// Function to delete the last element of the array
int deleteFromEnd(int arr[], int n) {
if (n <= 0) {
printf("Array is already empty!\n");
return 0;
}
// Just decrease size
return n - 1;
}

int main() {
int arr[10] = {10, 20, 30, 40, 50}; // Initial elements
int n = 5; // Size

// Delete the last element
n = deleteFromEnd(arr, n);

// Print updated array
printf("Array after deletion from the end: ");
for (int i = 0; i < n; i++) {
printf("%d ", arr[i]);
}
printf("\n");
return 0;

}
```



```
Array after deletion from the end: 10 20 30 40

Process returned 0 (0x0)   execution time : 0.094 s
Press any key to continue.
```

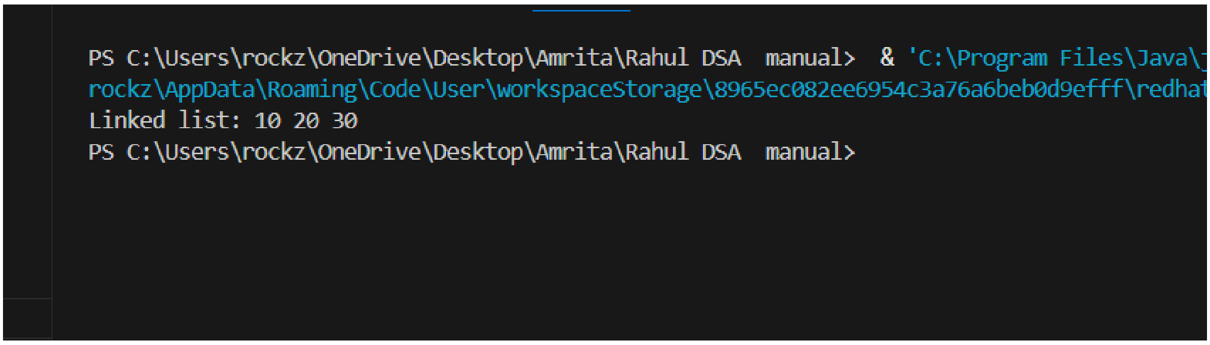
Lab-2   (07-2-25)

19. BUBBLE SORT
SELECTION SORT

Linked list creation

Display

```
class Node {

int data;

Node next;


Node(int value) {

this.data = value;

this.next = null;

}

}


class SinglyLinkedList {

private Node head;

private Node tail;


// Add a node at the end

public void add(int value) {

Node newNode = new Node(value);

if (head == null) {

head = newNode;

tail = newNode;

} else {

tail.next = newNode;

tail = newNode;
}
}

// Display the list
public void display() {
if (head == null) {
System.out.println("Linked list is empty.");
return;
}
Node temp = head;
System.out.print("Linked list: ");
while (temp != null) {
System.out.print(temp.data + " ");
temp = temp.next;
}
System.out.println();
}
}

// Main class containing the main method
public class Main {
public static void main(String[] args) {
SinglyLinkedList list = new SinglyLinkedList();

list.add(10);
list.add(20);
list.add(30);
list.display();

}

}
```

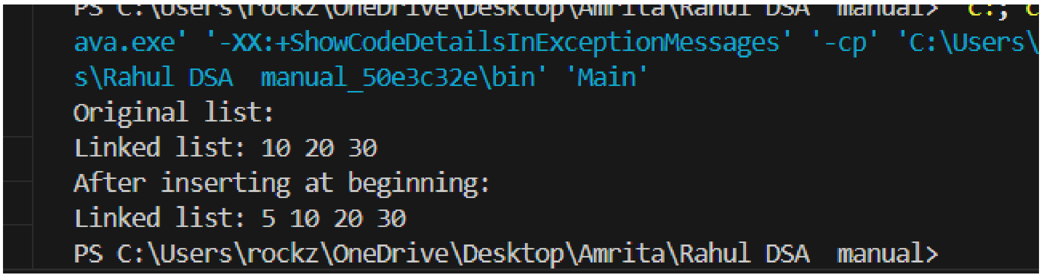


```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  & 'C:\Program Files\Java\
rockz\AppData\Roaming\Code\User\workspaceStorage\8965ec082ee6954c3a76a6beb0d9efff\redhat
Linked list: 10 20 30
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

20. Insert at start

```
class Node {
int data;
Node next;

Node(int value) {
this.data = value;
this.next = null;
}
}

class SinglyLinkedList {
private Node head;
private Node tail;

// Add a node at the end
public void add(int value) {
Node newNode = new Node(value);
if (head == null) {
head = newNode;
tail = newNode;
} else {
tail.next = newNode;
tail = newNode;
}
}

// Insert at beginning
public void insertatbegining(int value) {
Node newNode = new Node(value);
if (head == null) {
head = newNode;
tail = newNode;
} else {
newNode.next = head;
head = newNode;
}
}

// Display the list
public void display() {
if (head == null) {
System.out.println("Linked list is empty.");
return;
}
Node temp = head;
System.out.print("Linked list: ");
while (temp != null) {
System.out.print(temp.data + " ");
temp = temp.next;
}
System.out.println();
```

```
}

}


// Main class

public class Main {

public static void main(String[] args) {

SinglyLinkedList list = new SinglyLinkedList();


list.add(10);

list.add(20);

list.add(30);


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

list.display();


list.insertatbegining(5);

System.out.println("After inserting at beginning:");

list.display();

}

}
```

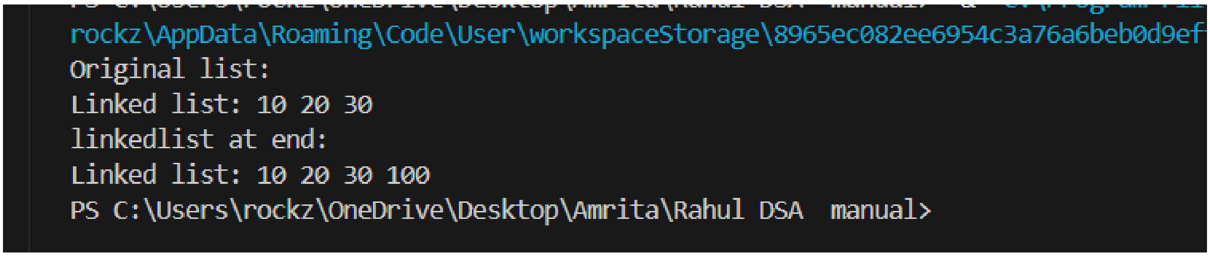


```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  c:; c
ava.exe' '-XX:+ShowCodeDetailsInExceptionMessages' '-cp' 'C:\Users\
s\Rahul DSA  manual_50e3c32e\bin' 'Main'
Original list:
Linked list: 10 20 30
After inserting at beginning:
Linked list: 5 10 20 30
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

21. At End

```
class Node {
int data;
Node next;

Node(int value) {
this.data = value;
this.next = null;
}
}

class SinglyLinkedList {
private Node head;
private Node tail;

// Add a node at the end
public void add(int value) {
Node newNode = new Node(value);
if (head == null) {
head = newNode;
tail = newNode;
} else {
tail.next = newNode;
tail = newNode;
}
}

public void insertatend(int value)
{
Node newNode=new Node(value);
if(head==null)
{
head=newNode;
tail=newNode;
}else{
tail.next=newNode;
tail=newNode;
}
}

// Display the list
public void display() {
if (head == null) {
System.out.println("Linked list is empty.");
return;
}
Node temp = head;
System.out.print("Linked list: ");
while (temp != null) {
System.out.print(temp.data + " ");
temp = temp.next;
}
System.out.println();
}
}
```

```
// Main class

public class Main {

public static void main(String[] args) {

SinglyLinkedList list = new SinglyLinkedList();


list.add(10);

list.add(20);

list.add(30);


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

list.display();




list.insertatend(100);

System.out.println("linkedlist at end:");

list.display();

}

}
```



```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual> & 'c:\Program Fil
rockz\AppData\Roaming\Code\User\workspaceStorage\8965ec082ee6954c3a76a6beb0d9ef
Original list:
Linked list: 10 20 30
linkedlist at end:
Linked list: 10 20 30 100
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

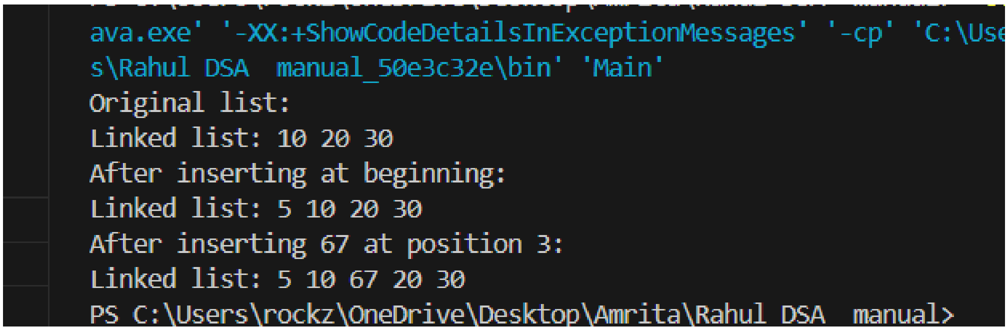
22. At Specific Position

```
class Node {

int data;

Node next;


Node(int value) {

this.data = value;

this.next = null;

}

}


class SinglyLinkedList {

private Node head;

private Node tail;


// Add a node at the end

public void add(int value) {

Node newNode = new Node(value);

if (head == null) {

head = newNode;

tail = newNode;

} else {

tail.next = newNode;

tail = newNode;

}

}


// Insert at the beginning
```

```
public void insertatbegining(int value) {

Node newNode = new Node(value);

if (head == null) {

head = newNode;

tail = newNode;

} else {

newNode.next = head;

head = newNode;

}

}


// Insert at specific position (1-based index)

public void insertatposition(int value, int pos) {

if (head == null || pos <= 1) {

insertatbegining(value);

return;

}


Node newNode = new Node(value);

Node temp = head;

int count = 1;


// Traverse to (pos - 1)th node or end of list

while (temp != null && count < pos - 1) {

temp = temp.next;

count++;

}
```

```
if (temp == null || temp.next == null) {
// If position is beyond current size, add at end
add(value);
} else {
newNode.next = temp.next;
temp.next = newNode;
}
}

// Display the list
public void display() {
if (head == null) {
System.out.println("Linked list is empty.");
return;
}
Node temp = head;
System.out.print("Linked list: ");
while (temp != null) {
System.out.print(temp.data + " ");
temp = temp.next;
}
System.out.println();
}
}

// Main class
public class Main {
public static void main(String[] args) {
```

```
SinglyLinkedList list = new SinglyLinkedList();

list.add(10);
list.add(20);
list.add(30);

System.out.println("Original list:");
list.display();

list.insertatbegining(5);
System.out.println("After inserting at beginning:");
list.display();

list.insertatposition(67, 3);
System.out.println("After inserting 67 at position 3:");
list.display();
}
}
```



```
ava.exe' '-XX:+ShowCodeDetailsInExceptionMessages' '-cp' 'C:\Use
s\Rahul DSA  manual_50e3c32e\bin' 'Main'
Original list:
Linked list: 10 20 30
After inserting at beginning:
Linked list: 5 10 20 30
After inserting 67 at position 3:
Linked list: 5 10 67 20 30
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

23. Delete at start

```
class Node {
int data;
Node next;

Node(int value) {
this.data = value;
this.next = null;
}
}

class SinglyLinkedList {
private Node head;
private Node tail;

// Add a node at the end
public void add(int value) {
Node newNode = new Node(value);
if (head == null) {
head = newNode;
tail = newNode;
} else {
tail.next = newNode;
tail = newNode;
}
}

// Insert at the beginning
```

```
public void insertatbegining(int value) {
Node newNode = new Node(value);
if (head == null) {
head = newNode;
tail = newNode;
} else {
newNode.next = head;
head = newNode;
}
}

// Insert at specific position (1-based index)
public void deleteatbegining()
{
if(head==null)
{
System.out.print("empty");
return;
}
if(head==tail)
{
head=null;
tail=null;
return;
}
Node temp=head;
head=head.next;
temp.next=null;
```

```
}

// Display the list
public void display() {
if (head == null) {
System.out.println("Linked list is empty.");
return;
}
Node temp = head;
System.out.print("Linked list: ");
while (temp != null) {
System.out.print(temp.data + " ");
temp = temp.next;
}
System.out.println();
}
}

// Main class
public class Main {
public static void main(String[] args) {
SinglyLinkedList list = new SinglyLinkedList();

list.add(10);
list.add(20);
list.add(30);

System.out.println("Original list:");
```

list.display();

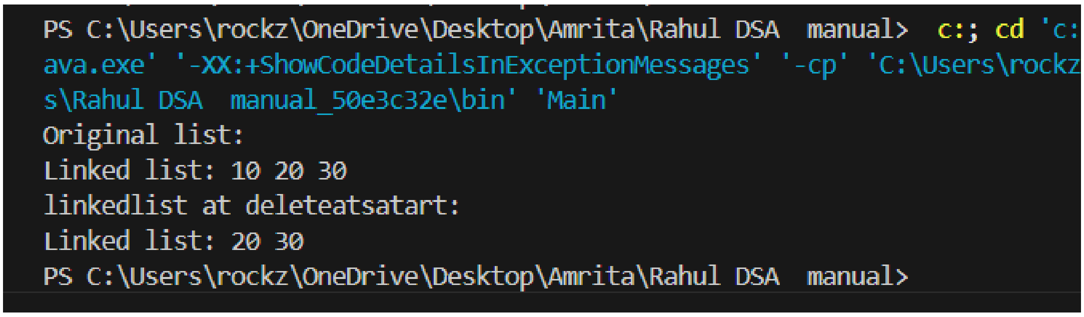
list.deleteatbegining();

System.out.println("linkedlist at deleteatsatart:");

list.display();

}

}

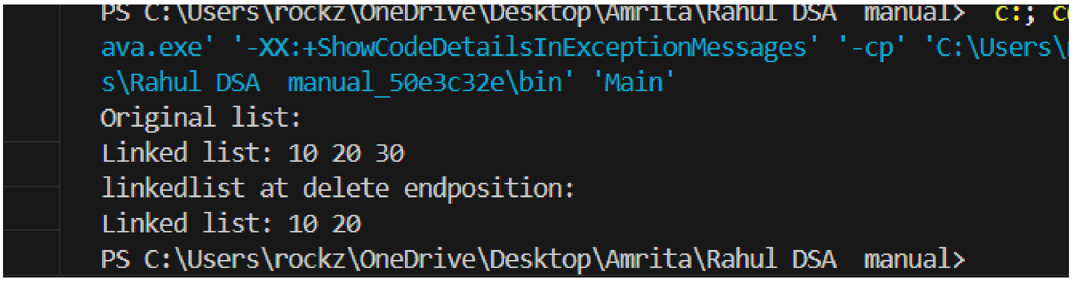


```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  c:; cd 'c:
ava.exe' '-XX:+ShowCodeDetailsInExceptionMessages' '-cp' 'C:\Users\rockz
s\Rahul DSA  manual_50e3c32e\bin' 'Main'
Original list:
Linked list: 10 20 30
linkedlist at deleteatsatart:
Linked list: 20 30
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

24. Delete END

```
class Node {
int data;
Node next;

Node(int value) {
this.data = value;
this.next = null;
}
}

class SinglyLinkedList {
private Node head;
private Node tail;

// Add a node at the end
public void add(int value) {
Node newNode = new Node(value);
if (head == null) {
head = newNode;
tail = newNode;
} else {
tail.next = newNode;
tail = newNode;
}
}

// Insert at the beginning
```

```
public void insertatbegining(int value) {
Node newNode = new Node(value);
if (head == null) {
head = newNode;
tail = newNode;
} else {
newNode.next = head;
head = newNode;
}
}

public void deleteatend()
{
if(head==null)
{
System.out.print("empty");
return;
}
if(head==tail)
{
head=null;
tail=null;
return;
}
Node temp=head;
while(temp.next!=tail)
{
temp=temp.next;
}
tail=temp;
temp.next=null;
}

// Display the list
public void display() {
if (head == null) {
System.out.println("Linked list is empty.");
return;
}
Node temp = head;
System.out.print("Linked list: ");
while (temp != null) {
System.out.print(temp.data + " ");
temp = temp.next;
}
System.out.println();
}
}

// Main class
public class Main {
public static void main(String[] args) {
SinglyLinkedList list = new SinglyLinkedList();

list.add(10);
list.add(20);
list.add(30);


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

list.display();


list.deleteatend();

System.out.println("linkedlist at delete endposition:");

list.display();

}

}
```



```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  c:; c
ava.exe' '-XX:+ShowCodeDetailsInExceptionMessages' '-cp' 'C:\Users\
s\Rahul DSA  manual_50e3c32e\bin' 'Main'
Original list:
Linked list: 10 20 30
linkedlist at delete endposition:
Linked list: 10 20
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

25. Delete specific POS

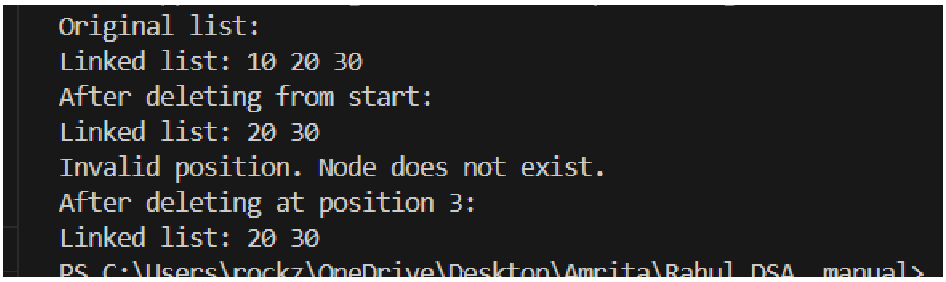
```
class Node {
int data;
Node next;

Node(int value) {
this.data = value;
this.next = null;
}
}

class SinglyLinkedList {
private Node head;
private Node tail;

// Add a node at the end
public void add(int value) {
Node newNode = new Node(value);
if (head == null) {
head = newNode;
tail = newNode;
} else {
tail.next = newNode;
tail = newNode;
}
}

// Insert at the beginning
```

```
public void insertatbegining(int value) {
Node newNode = new Node(value);
if (head == null) {
head = newNode;
tail = newNode;
} else {
newNode.next = head;
head = newNode;
}
}

// Delete from beginning
public void deleteatbegining() {
if (head == null) {
System.out.println("List is empty. Nothing to delete.");
return;
}
if (head == tail) {
head = null;
tail = null;
} else {
Node temp = head;
head = head.next;
temp.next = null;
}
}

// Delete at specific position (1-based index)
```

```
public void deleteatposition(int pos) {

if (head == null) {

System.out.println("List is empty. Nothing to delete.");

return;

}

if (pos <= 1) {

deleteatbegining();

return;

}


Node temp = head;

int count = 1;

// Traverse to (pos - 1)th node

while (temp != null && temp.next != null && count < pos - 1) {

temp = temp.next;

count++;

}


// Check if position is valid

if (temp.next == null) {

System.out.println("Invalid position. Node does not exist.");

return;

}


// If deleting the last node, update tail

if (temp.next == tail) {

tail = temp;

}
```

```
temp.next = temp.next.next;
}

// Display the list
public void display() {
if (head == null) {
System.out.println("Linked list is empty.");
return;
}
Node temp = head;
System.out.print("Linked list: ");
while (temp != null) {
System.out.print(temp.data + " ");
temp = temp.next;
}
System.out.println();
}
}

// Main class
public class Main {
public static void main(String[] args) {
SinglyLinkedList list = new SinglyLinkedList();

list.add(10);
list.add(20);
list.add(30);
```

```
System.out.println("Original list:");

list.display();


list.deleteatbegining();

System.out.println("After deleting from start:");

list.display();


list.deleteatposition(3);

System.out.println("After deleting at position 3:");

list.display();

}

}
```

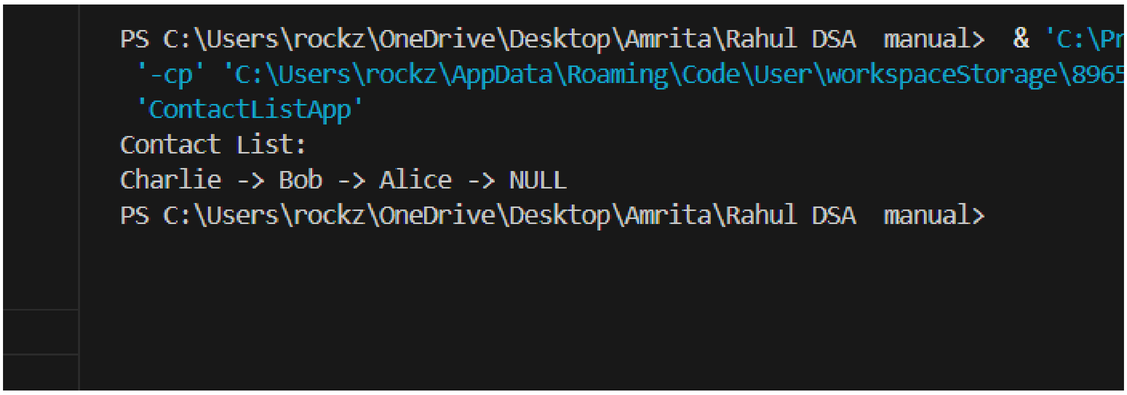


```
Original list:
Linked list: 10 20 30
After deleting from start:
Linked list: 20 30
Invalid position. Node does not exist.
After deleting at position 3:
Linked list: 20 30
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

26. Contact List Management

```
// Node class for contacts
class Contact {
String name;
Contact next;

public Contact(String name) {
this.name = name;
this.next = null;
}
}

// Linked List class to manage contacts
class ContactList {
Contact head;

// Add contact at the beginning
void addContact(String name) {
Contact newContact = new Contact(name);
newContact.next = head;
head = newContact;
}

// Display contacts
void displayContacts() {
Contact temp = head;
System.out.println("Contact List:");
while (temp != null) {
```

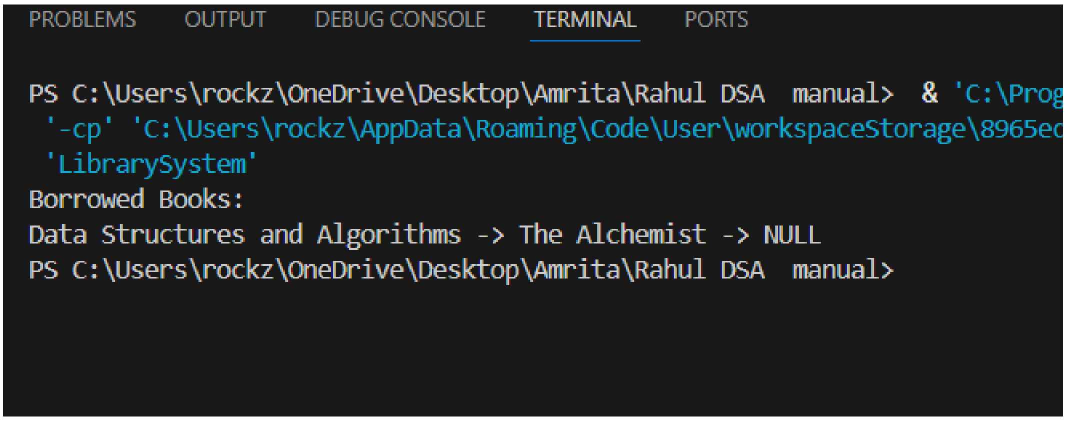
```
System.out.print(temp.name + " -> ");
temp = temp.next;
}
System.out.println("NULL");
}
}

// Main class
public class ContactListApp {
public static void main(String[] args) {
ContactList contacts = new ContactList();

contacts.addContact("Alice");
contacts.addContact("Bob");
contacts.addContact("Charlie");

contacts.displayContacts();
}
}
```



```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  & 'C:\Pr
 '-cp' 'C:\Users\rockz\AppData\Roaming\Code\User\workspaceStorage\8965
 'ContactListApp'
Contact List:
Charlie -> Bob -> Alice -> NULL
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

27. Book borrowing System in library

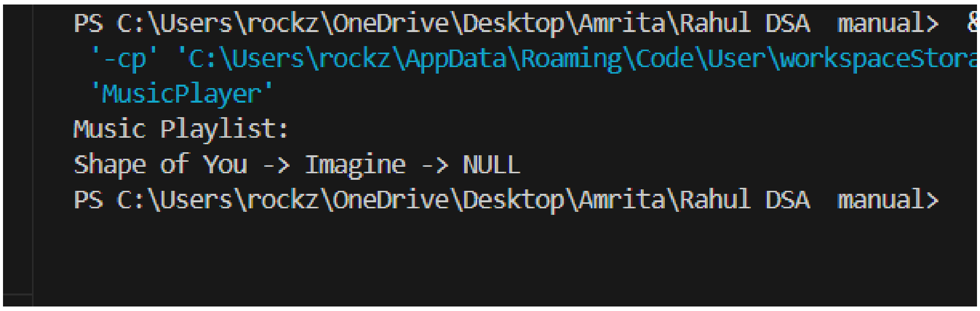
```
// Node class for books
class Book {
String title;
Book next;

public Book(String title) {
this.title = title;
this.next = null;
}
}

// Linked List for borrowed books
class BorrowedBooks {
Book head;

void borrowBook(String title) {
Book newBook = new Book(title);
newBook.next = head;
head = newBook;
}

void displayBorrowedBooks() {
Book temp = head;
System.out.println("Borrowed Books:");
while (temp != null) {
System.out.print(temp.title + " -> ");
temp = temp.next;
}

System.out.println("NULL");

}

}


// Main class

public class LibrarySystem {

public static void main(String[] args) {

BorrowedBooks library = new BorrowedBooks();


library.borrowBook("The Alchemist");

library.borrowBook("Data Structures and Algorithms");


library.displayBorrowedBooks();

}

}
```



```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  & 'C:\Prog
 '-cp' 'C:\Users\rockz\AppData\Roaming\Code\User\workspaceStorage\8965ec
 'LibrarySystem'
Borrowed Books:
Data Structures and Algorithms -> The Alchemist -> NULL
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

28. Music playlist System

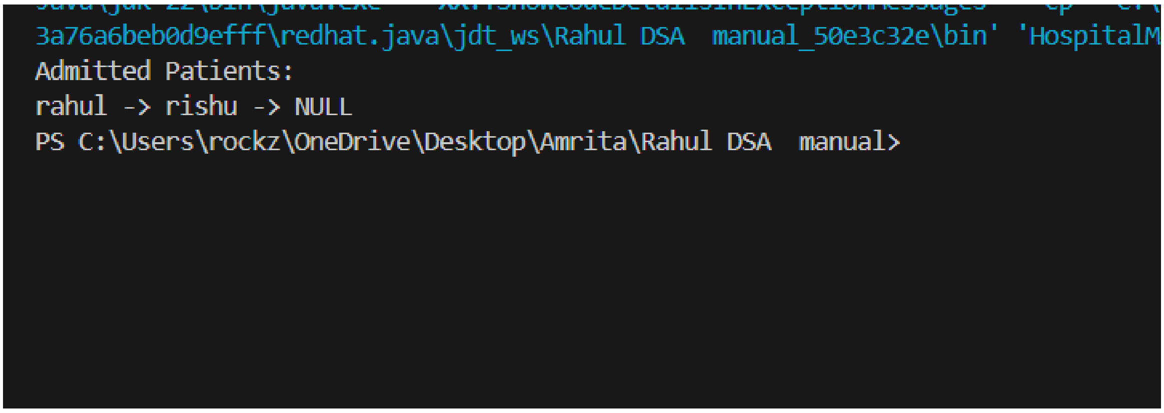
```
// Node class for songs
class Song {
String title;
Song next;

public Song(String title) {
this.title = title;
this.next = null;
}
}

// Linked List for playlist
class Playlist {
Song head;

void addSong(String title) {
Song newSong = new Song(title);
newSong.next = head;
head = newSong;
}

void displayPlaylist() {
Song temp = head;
System.out.println("Music Playlist:");
while (temp != null) {
System.out.print(temp.title + " -> ");
temp = temp.next;
}
System.out.println("NULL");
}
}

// Main class
public class MusicPlayer {
public static void main(String[] args) {
Playlist playlist = new Playlist();

playlist.addSong("Imagine");
playlist.addSong("Shape of You");

playlist.displayPlaylist();
}
}
```



```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  &
 '-cp' 'C:\Users\rockz\AppData\Roaming\Code\User\workspaceStora
 'MusicPlayer'
Music Playlist:
Shape of You -> Imagine -> NULL
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

29. Patient Record System in Hospital

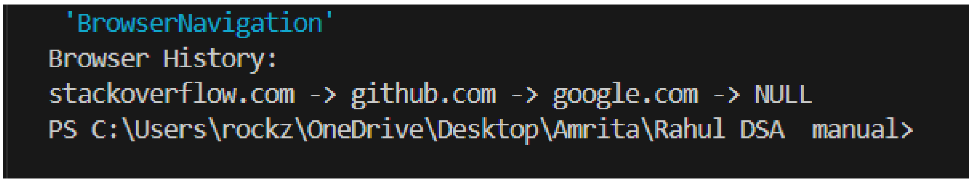
```
// Node class for patients
class Patient {
String name;
Patient next;

public Patient(String name) {
this.name = name;
this.next = null;
}
}

// Linked list class to manage patient records
class Hospital {
Patient head;

void admitPatient(String name) {
Patient newPatient = new Patient(name);
newPatient.next = head;
head = newPatient;
}

void displayPatients() {
Patient temp = head;
System.out.println("Admitted Patients:");
while (temp != null) {
System.out.print(temp.name + " -> ");
temp = temp.next;
}

System.out.println("NULL");

}

}


// Main class

public class HospitalManagement {

public static void main(String[] args) {

Hospital hospital = new Hospital();


hospital.admitPatient("rishu");

hospital.admitPatient("rishi");


hospital.displayPatients();

}

}
```



```
Java\jdk-22\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages' '-cp' 'C:\
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\bin' 'HospitalM
Admitted Patients:
rahul -> rishu -> NULL
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

30. Browser History Navigation

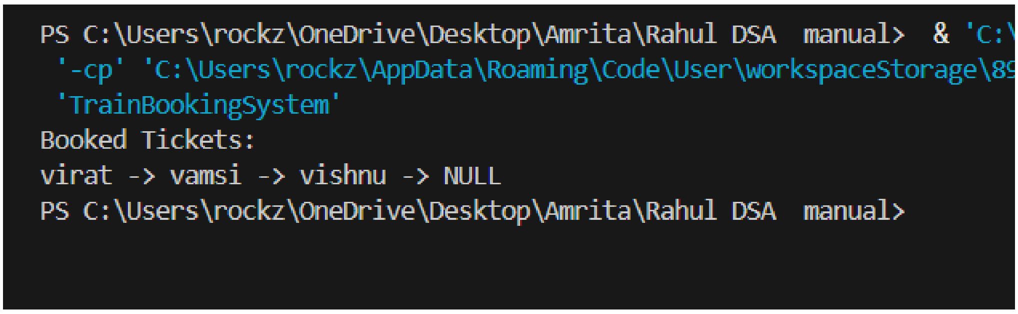
```
// Node class for web pages
class WebPage {
String url;
WebPage next;

public WebPage(String url) {
this.url = url;
this.next = null;
}
}

// Linked list class for managing browser history
class BrowserHistory {
WebPage head;

void visitPage(String url) {
WebPage newPage = new WebPage(url);
newPage.next = head;
head = newPage;
}

void displayHistory() {
WebPage temp = head;
System.out.println("Browser History:");
while (temp != null) {
System.out.print(temp.url + " -> ");
temp = temp.next;
}
System.out.println("NULL");
}
}

// Main class
public class BrowserNavigation {
public static void main(String[] args) {
BrowserHistory history = new BrowserHistory();

history.visitPage("google.com");
history.visitPage("github.com");
history.visitPage("stackoverflow.com");

history.displayHistory();
}
}
```



```
 'BrowserNavigation'
Browser History:
stackoverflow.com -> github.com -> google.com -> NULL
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

31. Train Ticket booking system

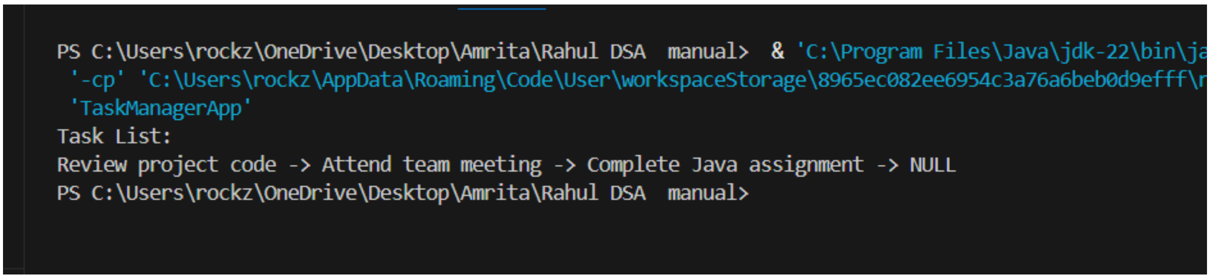
```
// Node class for train tickets
class Ticket {
String passengerName;
Ticket next;

public Ticket(String passengerName) {
this.passengerName = passengerName;
this.next = null;
}
}

// Linked list class to manage train tickets
class TrainTickets {
Ticket head;

void bookTicket(String passengerName) {
Ticket newTicket = new Ticket(passengerName);
newTicket.next = head;
head = newTicket;
}

void displayTickets() {
Ticket temp = head;
System.out.println("Booked Tickets:");
while (temp != null) {
System.out.print(temp.passengerName + " -> ");
temp = temp.next;
}
System.out.println("NULL");
}
}

// Main class
public class TrainBookingSystem {
public static void main(String[] args) {
TrainTickets train = new TrainTickets();

train.bookTicket("vishnu");
train.bookTicket("vamsi");
train.bookTicket("virat");

train.displayTickets();
}
}
```



```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  & 'C:\
 '-cp' 'C:\Users\rockz\AppData\Roaming\Code\User\workspaceStorage\89
 'TrainBookingSystem'
Booked Tickets:
virat -> vamsi -> vishnu -> NULL
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

32. Task Management System

```
// Node class for tasks
class Task {
String taskName;
Task next;

public Task(String taskName) {
this.taskName = taskName;
this.next = null;
}
}

// Linked list class for managing tasks
class TaskManager {
Task head;

void addTask(String taskName) {
Task newTask = new Task(taskName);
newTask.next = head;
head = newTask;
}

void displayTasks() {
Task temp = head;
System.out.println("Task List:");
while (temp != null) {

System.out.print(temp.taskName + " -> ");

temp = temp.next;

}

System.out.println("NULL");

}

}


// Main class

public class TaskManagerApp {

public static void main(String[] args) {

TaskManager tasks = new TaskManager();


tasks.addTask("Complete Java assignment");

tasks.addTask("Attend team meeting");

tasks.addTask("Review project code");


tasks.displayTasks();

}

}
```

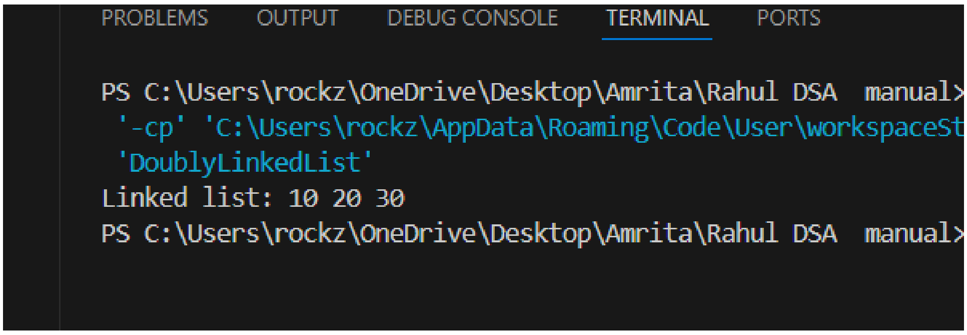


```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  & 'C:\Program Files\Java\jdk-22\bin\ja
 '-cp' 'C:\Users\rockz\AppData\Roaming\Code\User\workspaceStorage\8965ec082ee6954c3a76a6beb0d9efff\r
 'TaskManagerApp'
Task List:
Review project code -> Attend team meeting -> Complete Java assignment -> NULL
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

LAB-3 (14-2-25)

33. Creation Doubly Linked list

```
// Node class for Doubly Linked List
class DNode {
int data;
DNode next;
DNode prev;

DNode(int value) {
this.data = value;
this.next = null;
this.prev = null;
}
}

// Doubly Linked List class
public class DoublyLinkedList {
private DNode head;
private DNode tail;

// Add node to the end
public void add(int value) {
DNode newDNode = new DNode(value);
if (head == null) {
head = newDNode;
tail = newDNode;
} else {
tail.next = newDNode;
newDNode.prev = tail;
tail = newDNode;
}
}

// Display the list
public void display() {
if (head == null) {
System.out.println("Linked list is empty.");
return;
}
DNode temp = head;
System.out.print("Linked list: ");
while (temp != null) {
System.out.print(temp.data + " ");
temp = temp.next;
}
System.out.println();
}

// Main method inside the class
public static void main(String[] args) {
DoublyLinkedList dlist = new DoublyLinkedList();

dlist.add(10);
dlist.add(20);
dlist.add(30);


dlist.display();

}

}
```



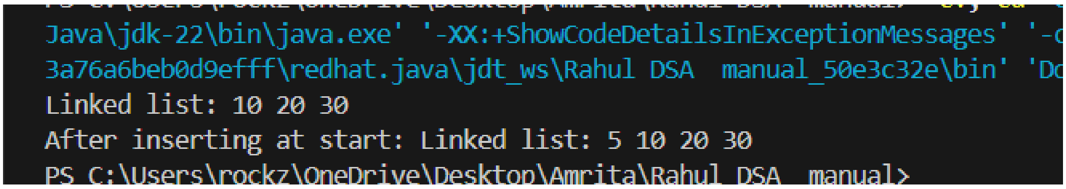
```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
 '-cp' 'C:\Users\rockz\AppData\Roaming\Code\User\workspaceSt
 'DoublyLinkedList'
Linked list: 10 20 30
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

34. DLL insertion (start)

```
// Node class for Doubly Linked List
class DNode {
int data;
DNode next;
DNode prev;

DNode(int value) {
this.data = value;
this.next = null;
this.prev = null;
}
}

// Doubly Linked List class
public class DoublyLinkedList {
private DNode head;
private DNode tail;

// Add node to the end
public void add(int value) {
DNode newDNode = new DNode(value);
if (head == null) {
head = newDNode;
tail = newDNode;
```

```
} else {
tail.next = newDNode;
newDNode.prev = tail;
tail = newDNode;
}
}

// Display the list
public void display() {
if (head == null) {
System.out.println("Linked list is empty.");
return;
}
DNode temp = head;
System.out.print("Linked list: ");
while (temp != null) {
System.out.print(temp.data + " ");
temp = temp.next;
}
System.out.println();
}

// Insert at the beginning
public void insertatbegining(int value) {
DNode newDNode = new DNode(value);
if (head == null) {
head = newDNode;
tail = newDNode;
```

```
} else {
newDNode.next = head;
head.prev = newDNode;
head = newDNode;
}
}

// Main method
public static void main(String[] args) {
DoublyLinkedList dlist = new DoublyLinkedList();

dlist.add(10);
dlist.add(20);
dlist.add(30);

dlist.display();

dlist.insertatbegining(5);
System.out.print("After inserting at start: ");
dlist.display();
}
}
```



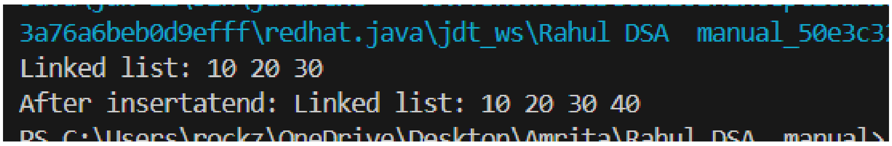
```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  c:; cd '
Java\jdk-22\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages' '-c
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\bin' 'Do
Linked list: 10 20 30
After inserting at start: Linked list: 5 10 20 30
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

35. DLL END

```
// Node class for Doubly Linked List

class DNode {

int data;

DNode next;

DNode prev;


DNode(int value) {

this.data = value;

this.next = null;

this.prev = null;

}

}


// Doubly Linked List class

public class DoublyLinkedList {

private DNode head;

private DNode tail;


// Add node to the end
```

```
public void add(int value) {
DNode newDNode = new DNode(value);
if (head == null) {
head = newDNode;
tail = newDNode;
} else {
tail.next = newDNode;
newDNode.prev = tail;
tail = newDNode;
}
}

// Insert at end (alternative to add)
public void insertatend(int value) {
DNode newDNode = new DNode(value);
if (head == null) {
head = newDNode;
tail = newDNode;
} else {
tail.next = newDNode;
newDNode.prev = tail;
tail = newDNode;
}
}

// Display the list
public void display() {
if (head == null) {
```

```
System.out.println("Linked list is empty.");
return;
}
DNode temp = head;
System.out.print("Linked list: ");
while (temp != null) {
System.out.print(temp.data + " ");
temp = temp.next;
}
System.out.println();
}

// Main method
public static void main(String[] args) {
DoublyLinkedList dlist = new DoublyLinkedList();

dlist.add(10);
dlist.add(20);
dlist.add(30);
dlist.display();

dlist.insertatend(40);
System.out.print("After insertatend: ");
dlist.display();
}
}
```



```
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c3
Linked list: 10 20 30
After insertatend: Linked list: 10 20 30 40
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

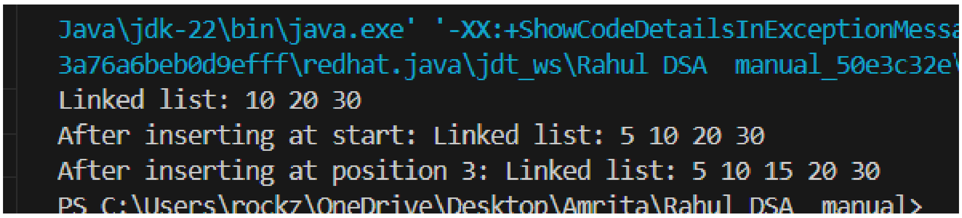
36. DLL specific position

```
// Node class for Doubly Linked List
class DNode {
int data;
DNode next;
DNode prev;

DNode(int value) {
this.data = value;
this.next = null;
this.prev = null;
}
}

// Doubly Linked List class
public class DoublyLinkedList {
private DNode head;
private DNode tail;

// Add node to the end
public void add(int value) {
```

```
DNode newDNode = new DNode(value);

if (head == null) {

head = newDNode;

tail = newDNode;

} else {

tail.next = newDNode;

newDNode.prev = tail;

tail = newDNode;

}

}


// Display the list

public void display() {

if (head == null) {

System.out.println("Linked list is empty.");

return;

}

DNode temp = head;

System.out.print("Linked list: ");

while (temp != null) {

System.out.print(temp.data + " ");

temp = temp.next;

}

System.out.println();

}


// Insert at the beginning

public void insertatbegining(int value) {
```

```
DNode newDNode = new DNode(value);
if (head == null) {
head = newDNode;
tail = newDNode;
} else {
newDNode.next = head;
head.prev = newDNode;
head = newDNode;
}
}

// Insert at the end
public void insertatend(int value) {
add(value); // Using existing add() method
}

// Insert at specific position (1-based index)
public void insertatposition(int value, int pos) {
if (head == null || pos <= 1) {
insertatbegining(value);
return;
}

DNode newDNode = new DNode(value);
DNode temp = head;

// Traverse to (pos - 1)th node
for (int i = 1; i < pos - 1 && temp.next != null; i++) {
```

```
temp = temp.next;
}

// If inserting at the end
if (temp.next == null) {
insertatend(value);
return;
}

// Insert in the middle
newDNode.next = temp.next;
newDNode.prev = temp;
temp.next.prev = newDNode;
temp.next = newDNode;
}

// Main method
public static void main(String[] args) {
DoublyLinkedList dlist = new DoublyLinkedList();

dlist.add(10);
dlist.add(20);
dlist.add(30);
dlist.display();

dlist.insertatbegining(5);
System.out.print("After inserting at start: ");
dlist.display();
dlist.insertatposition(15, 3); // Inserting at position 3

System.out.print("After inserting at position 3: ");

dlist.display();

}

}
```



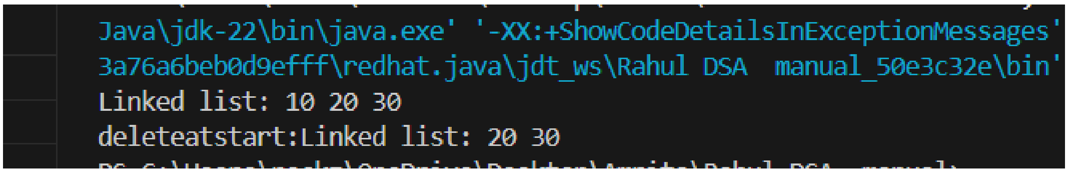
```
Java\jdk-22\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessa
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\
Linked list: 10 20 30
After inserting at start: Linked list: 5 10 20 30
After inserting at position 3: Linked list: 5 10 15 20 30
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

37. DLL (deletion form start)

```
// Node class for Doubly Linked List
class DNode {
int data;
DNode next;
DNode prev;

DNode(int value) {
this.data = value;
this.next = null;
this.prev = null;
}
}

// Doubly Linked List class
public class DoublyLinkedList {
private DNode head;
private DNode tail;

// Add node to the end
public void add(int value) {
DNode newDNode = new DNode(value);
if (head == null) {
```

```
head = newDNode;

tail = newDNode;

} else {

tail.next = newDNode;

newDNode.prev = tail;

tail = newDNode;

}

}


public void deletefrombegining()

{

if(head==null)

{

System.out.println("empty");

return;

}

if(head==tail)

{

head=null;

tail=null;

}

head=head.next;

head.prev=null;

}


// Display the list

public void display() {

if (head == null) {
```

```
System.out.println("Linked list is empty.");
return;
}
DNode temp = head;
System.out.print("Linked list: ");
while (temp != null) {
System.out.print(temp.data + " ");
temp = temp.next;
}
System.out.println();
}

// Main method
public static void main(String[] args) {
DoublyLinkedList dlist = new DoublyLinkedList();

dlist.add(10);
dlist.add(20);
dlist.add(30);
dlist.display();
dlist.deletefrombegining();
System.out.print("deleteatstart:");
dlist.display();
}
}
```



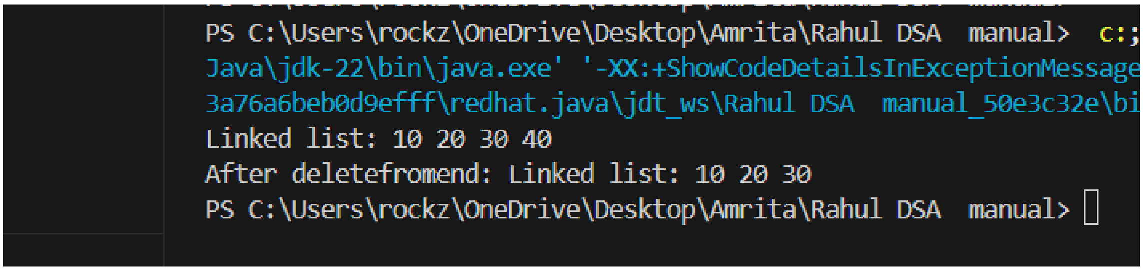
```
Java\jdk-22\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages'
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\bin'
Linked list: 10 20 30
deleteatstart:Linked list: 20 30
```

38. DLL deletion at end

```
// Node class for Doubly Linked List

class DNode {

int data;

DNode next;

DNode prev;


DNode(int value) {

this.data = value;

this.next = null;

this.prev = null;

}

}


// Doubly Linked List class

public class DoublyLinkedList {

private DNode head;

private DNode tail;


// Add node to the end

public void add(int value) {
```

```
DNode newDNode = new DNode(value);
if (head == null) {
head = newDNode;
tail = newDNode;
} else {
tail.next = newDNode;
newDNode.prev = tail;
tail = newDNode;
}
}

// Delete from the end
public void deletefromend() {
if (head == null) {
System.out.println("List is already empty.");
return;
}
if (head == tail) {
head = null;
tail = null;
} else {
tail = tail.prev;
tail.next = null;
}
}

// Display the list
```

```
public void display() {
if (head == null) {
System.out.println("Linked list is empty.");
return;
}
DNode temp = head;
System.out.print("Linked list: ");
while (temp != null) {
System.out.print(temp.data + " ");
temp = temp.next;
}
System.out.println();
}

// Main method
public static void main(String[] args) {
DoublyLinkedList dlist = new DoublyLinkedList();

dlist.add(10);
dlist.add(20);
dlist.add(30);
dlist.add(40);
dlist.display();



dlist.deletefromend(); // deletes 40
System.out.print("After deletefromend: ");
dlist.display();
}

}
```



```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  c:;
Java\jdk-22\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessage
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\bi
Linked list: 10 20 30 40
After deletefromend: Linked list: 10 20 30
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual> 
```

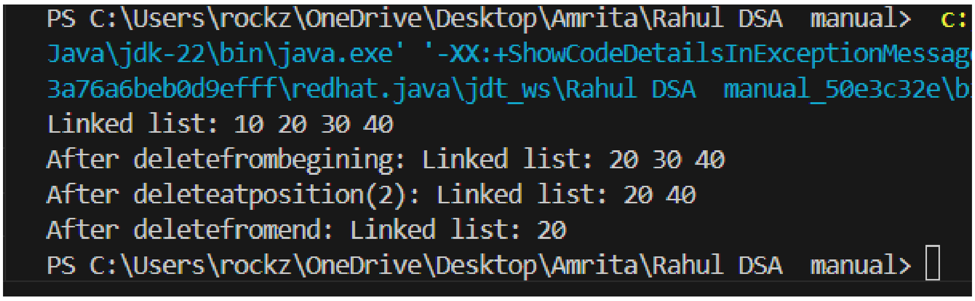
39. DLL deletion from specific pos

```
// Node class for Doubly Linked List
class DNode {
int data;
DNode next;
DNode prev;

DNode(int value) {
this.data = value;
this.next = null;
this.prev = null;
}
}

// Doubly Linked List class
public class DoublyLinkedList {
private DNode head;
private DNode tail;

// Add node to the end
public void add(int value) {
DNode newDNode = new DNode(value);
if (head == null) {
```

```
head = newDNode;
tail = newDNode;
} else {
tail.next = newDNode;
newDNode.prev = tail;
tail = newDNode;
}
}

// Delete from the beginning
public void deletefrombegining() {
if (head == null) {
System.out.println("List is already empty.");
return;
}
if (head == tail) {
head = null;
tail = null;
} else {
head = head.next;
head.prev = null;
}
}

// Delete from the end
public void deletefromend() {
if (head == null) {
System.out.println("List is already empty.");
```

```
return;

}

if (head == tail) {

head = null;

tail = null;

} else {

tail = tail.prev;

tail.next = null;

}

}


// Delete from a given position

public void deleteatposition(int pos) {

if (head == null) {

System.out.println("List is empty.");

return;

}


if (pos <= 1) {

deletefrombegining();

return;

}


DNode temp = head;

for (int i = 1; i < pos - 1; i++) {

if (temp.next == null) {

System.out.println("Position out of bounds.");

return;
}
temp = temp.next;
}

if (temp.next == null || temp.next == tail) {
deletefromend();
return;
}

DNode toDelete = temp.next;
temp.next = toDelete.next;

if (toDelete.next != null) {
toDelete.next.prev = temp;
}
}

// Display the list
public void display() {
if (head == null) {
System.out.println("Linked list is empty.");
return;
}
DNode temp = head;
System.out.print("Linked list: ");
while (temp != null) {
System.out.print(temp.data + " ");
temp = temp.next;
```

```
}

System.out.println();

}


// Main method

public static void main(String[] args) {

DoublyLinkedList dlist = new DoublyLinkedList();


dlist.add(10);

dlist.add(20);

dlist.add(30);

dlist.add(40);

dlist.display();


dlist.deletefrombegining();

System.out.print("After deletefrombegining: ");

dlist.display();


dlist.deleteatposition(2); // deletes 30

System.out.print("After deleteatposition(2): ");

dlist.display();


dlist.deletefromend(); // deletes 40

System.out.print("After deletefromend: ");

dlist.display();

}

}
```



```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  c:
Java\jdk-22\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessag
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\b
Linked list: 10 20 30 40
After deletefrombegining: Linked list: 20 30 40
After deleteatposition(2): Linked list: 20 40
After deletefromend: Linked list: 20
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual> 
```

LAB_4 (21-02-25)

40. Circular Singly Linked list

Insertion at start

```
class CNode

{

int data;

CNode next;

CNode(int value)

{

this.data=value;

this.next=null;

}

}

public class CircularLinkedList

{

private CNode head;

private CNode tail;


public void add(int value)
```

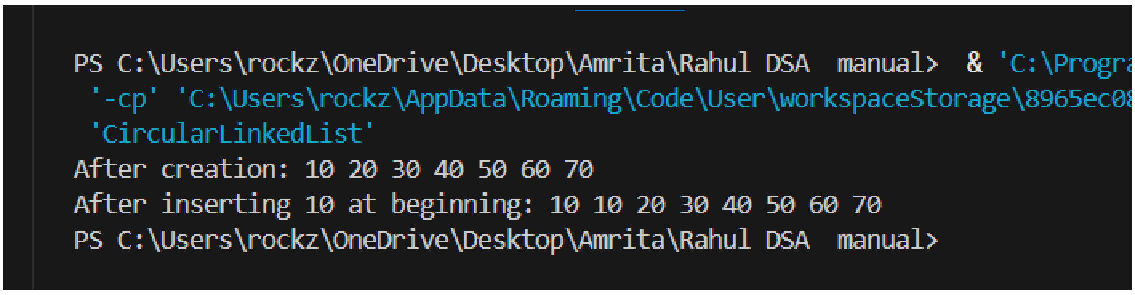
```
{
CNode newCNode=new CNode(value);
if(head==null)
{
head=newCNode;
tail=newCNode;
}else{
tail.next=newCNode;
tail=newCNode;
tail.next=head;
}
}
public void display()
{
if(head==null)
{
System.out.print("empty");
return;
}
CNode temp=head;
do{
System.out.print(temp.data+" ");
temp=temp.next;
}while(temp!=head);
{
System.out.println();
}
}
```

```
public void insertatbegining(int value)
{
CNode newCNode=new CNode(value);
if(head==null)
{
head=newCNode;
tail=newCNode;
newCNode.next=head;
}else{
newCNode.next=head;
head=newCNode;
tail.next=newCNode;
}
}
public static void main(String[] args)
{
CircularLinkedList clist = new CircularLinkedList();
clist.add(10);
clist.add(20);
clist.add(30);
clist.add(40);
clist.add(50);
clist.add(60);
clist.add(70);
System.out.print("After creation: ");
clist.display();
clist.insertatbegining(10);
System.out.print("After inserting 10 at beginning: ");
```

clist.display();

}

}



```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  & 'C:\Progra
 '-cp' 'C:\Users\rockz\AppData\Roaming\Code\User\workspaceStorage\8965ec08
 'CircularLinkedList'
After creation: 10 20 30 40 50 60 70
After inserting 10 at beginning: 10 10 20 30 40 50 60 70
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

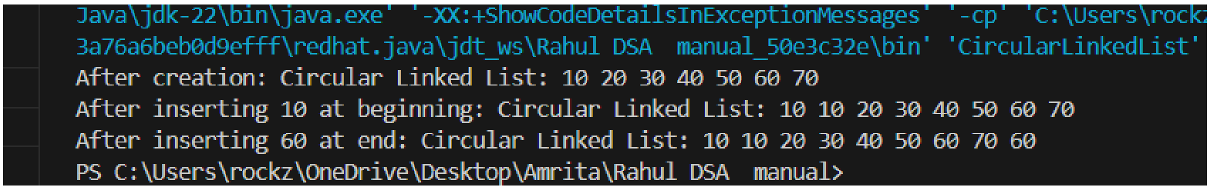
41. Insertion at end

```
class CNode {

int data;

CNode next;


CNode(int value) {

this.data = value;

this.next = null;

}

}


public class CircularLinkedList {

private CNode head;

private CNode tail;
```

```
public void add(int value) {

CNode newCNode = new CNode(value);

if (head == null) {

head = newCNode;

tail = newCNode;

tail.next = head;

} else {

tail.next = newCNode;

tail = newCNode;

tail.next = head;

}

}


public void deletefromend() {

if (head == null) {

System.out.println("List is empty.");

return;

}

if (head == tail) {

head = null;

tail = null;

return;

}

CNode temp = head;

while (temp.next != tail) {

temp = temp.next;

}

tail = temp;
```

```
tail.next = head;
}

public void insertatbegining(int value) {
CNode newCNode = new CNode(value);
if (head == null) {
head = newCNode;
tail = newCNode;
newCNode.next = head;
} else {
newCNode.next = head;
head = newCNode;
tail.next = head;
}
}

public void insertatend(int value) {
add(value); // Reuse the add method since it already handles insertion at end
}

public void display() {
if (head == null) {
System.out.println("List is empty.");
return;
}
CNode temp = head;
System.out.print("Circular Linked List: ");
do {
```

```
System.out.print(temp.data + " ");
temp = temp.next;
} while (temp != head);
System.out.println();
}

public static void main(String[] args) {
CircularLinkedList clist = new CircularLinkedList();
clist.add(10);
clist.add(20);
clist.add(30);
clist.add(40);
clist.add(50);
clist.add(60);
clist.add(70);
System.out.print("After creation: ");
clist.display();

clist.insertatbegining(10);
System.out.print("After inserting 10 at beginning: ");
clist.display();

clist.insertatend(60);
System.out.print("After inserting 60 at end: ");
clist.display();
}
}
```



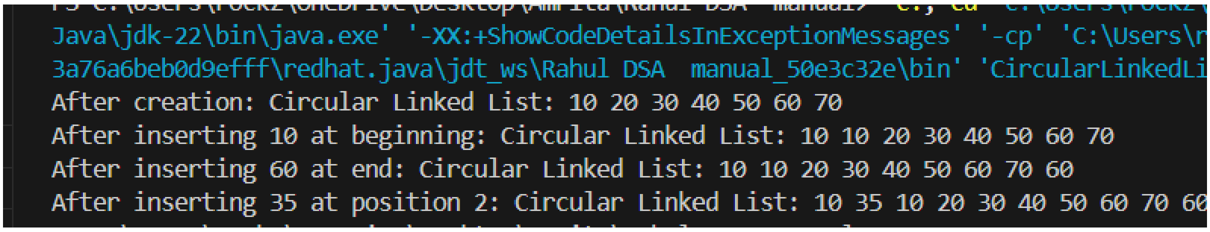
```
Java\jdk-22\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages' '-cp' 'C:\Users\rock
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\bin' 'CircularLinkedList'
After creation: Circular Linked List: 10 20 30 40 50 60 70
After inserting 10 at beginning: Circular Linked List: 10 10 20 30 40 50 60 70
After inserting 60 at end: Circular Linked List: 10 10 20 30 40 50 60 70 60
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

42. Insertion at Specific position

```
class CNode {
int data;
CNode next;

CNode(int value) {
this.data = value;
this.next = null;
}
}

public class CircularLinkedList {
private CNode head;
private CNode tail;

public void add(int value) {
CNode newCNode = new CNode(value);
if (head == null) {
head = newCNode;
tail = newCNode;
tail.next = head;
} else {
tail.next = newCNode;
tail = newCNode;
tail.next = head;
}
}
```

```
public void deletefromend() {
if (head == null) {
System.out.println("List is empty.");
return;
}
if (head == tail) {
head = null;
tail = null;
return;
}
CNode temp = head;
while (temp.next != tail) {
temp = temp.next;
}
tail = temp;
tail.next = head;
}

public void insertatbegining(int value) {
CNode newCNode = new CNode(value);
if (head == null) {
head = newCNode;
tail = newCNode;
newCNode.next = head;
} else {
newCNode.next = head;
head = newCNode;
tail.next = head;
}
}

public void insertatend(int value) {
add(value);
}

public void insertatposition(int value, int pos) {
if (head == null || pos <= 1) {
insertatbegining(value);
return;
}

CNode newCNode = new CNode(value);
CNode temp = head;

for (int i = 1; i < pos - 1 && temp.next != head; i++) {
temp = temp.next;
}

newCNode.next = temp.next;
temp.next = newCNode;

if (temp == tail) {
tail = newCNode;
}
}
```

```
public void display() {

if (head == null) {

System.out.println("List is empty.");

return;

}

CNode temp = head;

System.out.print("Circular Linked List: ");

do {

System.out.print(temp.data + " ");

temp = temp.next;

} while (temp != head);

System.out.println();

}


public static void main(String[] args) {

CircularLinkedList clist = new CircularLinkedList();

clist.add(10);

clist.add(20);

clist.add(30);

clist.add(40);

clist.add(50);

clist.add(60);

clist.add(70);

System.out.print("After creation: ");

clist.display();


clist.insertatbegining(10);
System.out.print("After inserting 10 at beginning: ");

clist.display();


clist.insertatend(60);

System.out.print("After inserting 60 at end: ");

clist.display();


clist.insertatposition(35, 2);

System.out.print("After inserting 35 at position 2: ");

clist.display();

}

}
```

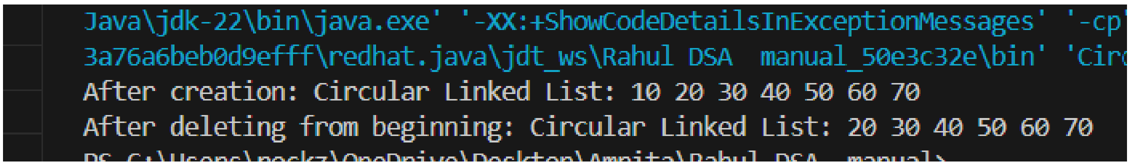


```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual> c:; cd 'c:\Users\rockz\
Java\jdk-22\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages' '-cp' 'C:\Users\r
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\bin' 'CircularLinkedLi
After creation: Circular Linked List: 10 20 30 40 50 60 70
After inserting 10 at beginning: Circular Linked List: 10 10 20 30 40 50 60 70
After inserting 60 at end: Circular Linked List: 10 10 20 30 40 50 60 70 60
After inserting 35 at position 2: Circular Linked List: 10 35 10 20 30 40 50 60 70 60
```

43. Deletion from start

```
class CNode {
int data;
CNode next;

CNode(int value) {
this.data = value;
this.next = null;
}
}

public class CircularLinkedList {
private CNode head;
private CNode tail;

public void add(int value) {
CNode newCNode = new CNode(value);
if (head == null) {
head = newCNode;
tail = newCNode;
tail.next = head;
} else {
tail.next = newCNode;
tail = newCNode;
tail.next = head;
}
}
```

```
public void deletefromend() {
if (head == null) {
System.out.println("List is empty.");
return;
}
if (head == tail) {
head = null;
tail = null;
return;
}
CNode temp = head;
while (temp.next != tail) {
temp = temp.next;
}
tail = temp;
tail.next = head;
}
public void deletefrombegining()
{
if(head==null)
{
System.out.print("empty");
return;
}
if(head==tail)
{
head=null;
tail=null;
return;
}
head=head.next;
tail.next=head;
}
public void display() {
if (head == null) {
System.out.println("List is empty.");
return;
}
CNode temp = head;
System.out.print("Circular Linked List: ");
do {
System.out.print(temp.data + " ");
temp = temp.next;
} while (temp != head);
System.out.println();
}

public static void main(String[] args) {
CircularLinkedList clist = new CircularLinkedList();
clist.add(10);
clist.add(20);
clist.add(30);
clist.add(40);
clist.add(50);
clist.add(60);
clist.add(70);

System.out.print("After creation: ");

clist.display();

clist.deletefrombegining();

System.out.print("After deleting from beginning: ");

clist.display();

}
```

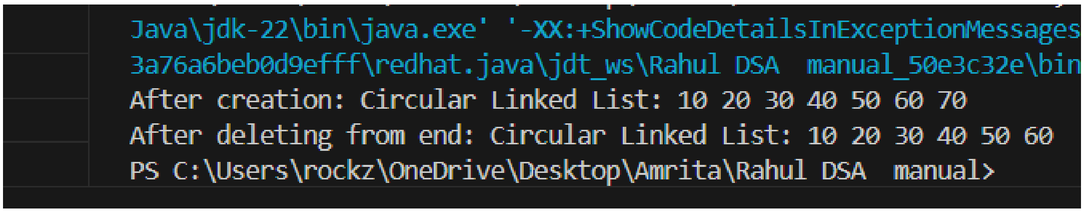


```
Java\jdk-22\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages' '-cp'
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\bin' 'Cir
After creation: Circular Linked List: 10 20 30 40 50 60 70
After deleting from beginning: Circular Linked List: 20 30 40 50 60 70
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

44. Deletion at End

```
class CNode {
int data;
CNode next;

CNode(int value) {
this.data = value;
this.next = null;
}
}

public class CircularLinkedList {
private CNode head;
private CNode tail;

public void add(int value) {
CNode newCNode = new CNode(value);
if (head == null) {
head = newCNode;
tail = newCNode;
tail.next = head;
} else {
tail.next = newCNode;
tail = newCNode;
tail.next = head;
}
}

public void deletefromend() {
if (head == null) {
System.out.println("List is empty.");
return;
}
if (head == tail) {
head = null;
tail = null;
return;
}
CNode temp = head;
while (temp.next != tail) {
temp = temp.next;
}
tail = temp;
tail.next = head;
}

public void display() {
if (head == null) {
System.out.println("List is empty.");
return;
}
CNode temp = head;
System.out.print("Circular Linked List: ");
```

```
do {

System.out.print(temp.data + " ");

temp = temp.next;

} while (temp != head);

System.out.println();

}


public static void main(String[] args) {

CircularLinkedList clist = new CircularLinkedList();

clist.add(10);

clist.add(20);

clist.add(30);

clist.add(40);

clist.add(50);

clist.add(60);

clist.add(70);

System.out.print("After creation: ");

clist.display();

clist.deletefromend();

System.out.print("After deleting from end: ");

clist.display();

}

}
```



```
Java\jdk-22\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\bin
After creation: Circular Linked List: 10 20 30 40 50 60 70
After deleting from end: Circular Linked List: 10 20 30 40 50 60
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

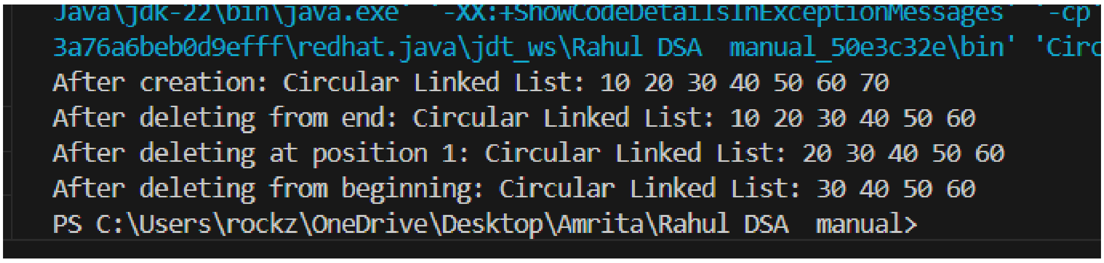
45. Deletion at specific position

```
class CNode {
int data;
CNode next;

CNode(int value) {
this.data = value;
this.next = null;
}
}

public class CircularLinkedList {
private CNode head;
private CNode tail;

public void add(int value) {
CNode newCNode = new CNode(value);
if (head == null) {
head = newCNode;
tail = newCNode;
tail.next = head;
} else {
tail.next = newCNode;
tail = newCNode;
tail.next = head;
}
}

public void deletefrombegining() {
if (head == null) {
System.out.println("List is empty.");
return;
}
if (head == tail) {
head = null;
tail = null;
return;
}
head = head.next;
tail.next = head;
}

public void deletefromend() {
if (head == null) {
System.out.println("List is empty.");
return;
}
if (head == tail) {
head = null;
tail = null;
return;
}
```

```
CNode temp = head;

while (temp.next != tail) {

temp = temp.next;

}

tail = temp;

tail.next = head;

}


public void deleteatposition(int pos) {

if (head == null) {

System.out.println("List is empty.");

return;

}


if (pos <= 1) {

deletefrombegining();

return;

}


CNode temp = head;

for (int i = 1; i < pos - 1 && temp.next != head; i++) {

temp = temp.next;

}


// If trying to delete the last node

if (temp.next == tail) {

deletefromend();

} else {
```

```
temp.next = temp.next.next;

}

}


public void display() {

if (head == null) {

System.out.println("List is empty.");

return;

}

CNode temp = head;

System.out.print("Circular Linked List: ");

do {

System.out.print(temp.data + " ");

temp = temp.next;

} while (temp != head);

System.out.println();

}


public static void main(String[] args) {

CircularLinkedList clist = new CircularLinkedList();

clist.add(10);

clist.add(20);

clist.add(30);

clist.add(40);

clist.add(50);

clist.add(60);

clist.add(70);
```

```
System.out.print("After creation: ");

clist.display();


clist.deletefromend();

System.out.print("After deleting from end: ");

clist.display();


clist.deleteatposition(1);

System.out.print("After deleting at position 1: ");

clist.display();


clist.deletefrombegining();

System.out.print("After deleting from beginning: ");

clist.display();

}

}
```



```
Java\jdk-22\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages' '-cp'
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\bin' 'Circ
After creation: Circular Linked List: 10 20 30 40 50 60 70
After deleting from end: Circular Linked List: 10 20 30 40 50 60
After deleting at position 1: Circular Linked List: 20 30 40 50 60
After deleting from beginning: Circular Linked List: 30 40 50 60
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

46. Circular Doubly Linked LIST

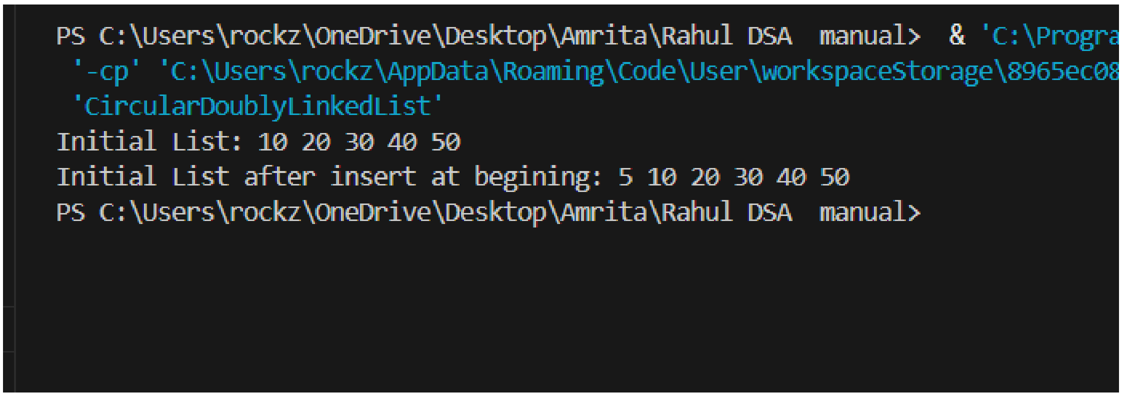
Insertion at start

```
class CDNode
{
int data;
CDNode next;
CDNode prev;
CDNode(int value)
{
this.data=value;
this.next=null;
this.prev=null;
}
}
public class CircularDoublyLinkedList
{
private CDNode head;
private CDNode tail;

public void add(int value)
{
CDNode newNode=new CDNode(value);
if(head==null)
{
```

```
head=newNode;
tail=newNode;
head.next=head;
head.prev=head;
}else{
tail.next=newNode;
newNode.prev=tail;
tail=newNode;
tail.next=head;
head.prev=tail;
}
}
public void display()
{
if(head==null)
{
System.out.print("empty");
return;
}
CDNode temp=head;
do {
System.out.print(temp.data+" ");
temp=temp.next;
} while (temp!=head);
System.out.println();
}
public void insertatbegining(int value)
{
```

```
CDNode newNode=new CDNode(value);
if(head==null)
{
head=newNode;
tail = newNode;
newNode.next = newNode;
newNode.prev = newNode;
} else {
newNode.next = head;
newNode.prev = tail;
head.prev = newNode;
tail.next = newNode;
head = newNode;

}
}
public static void main(String[] args) {
CircularDoublyLinkedList cdList = new CircularDoublyLinkedList();

cdList.add(10);
cdList.add(20);
cdList.add(30);
cdList.add(40);
cdList.add(50);
System.out.print("Initial List: ");
cdList.display();
cdList.insertatbegining(5);
System.out.print("Initial List after insert at begining: ");
```

```
cdList.display();

}

}
```



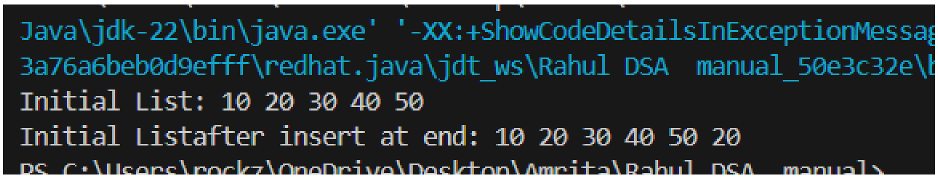
```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  & 'C:\Progra
 '-cp' 'C:\Users\rockz\AppData\Roaming\Code\User\workspaceStorage\8965ec08
 'CircularDoublyLinkedList'
Initial List: 10 20 30 40 50
Initial List after insert at begining: 5 10 20 30 40 50
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

47. Insertion at End

```
class CDNode

{

int data;

CDNode next;

CDNode prev;

CDNode(int value)

{

this.data=value;

this.next=null;

this.prev=null;

}

}

public class CircularDoublyLinkedList

{
```

```
private CDNode head;
private CDNode tail;

public void add(int value)
{
CDNode newNode=new CDNode(value);
if(head==null)
{
head=newNode;
tail=newNode;
head.next=head;
head.prev=head;
}else{
tail.next=newNode;
newNode.prev=tail;
tail=newNode;
tail.next=head;
head.prev=tail;
}
}
public void display()
{
if(head==null)
{
System.out.print("empty");
return;
}
CDNode temp=head;
```

```
do {
System.out.print(temp.data+" ");
temp=temp.next;
} while (temp!=head);
System.out.println();
}
public void insertAtEnd(int value) {
CDNode newNode = new CDNode(value);
if (head == null) {
head = newNode;
tail = newNode;
newNode.next = newNode;
newNode.prev = newNode;
} else {
newNode.next = head;
newNode.prev = tail;
tail.next = newNode;
head.prev = newNode;
tail = newNode;
}
}
public static void main(String[] args) {
CircularDoublyLinkedList cdList = new CircularDoublyLinkedList();

cdList.add(10);
cdList.add(20);
cdList.add(30);
cdList.add(40);
cdList.add(50);

System.out.print("Initial List: ");

cdList.display();

cdList.insertAtEnd(20);

System.out.print("Initial Listafter insert at end: ");

cdList.display();

}

}
```



```
Java\jdk-22\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessag
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\b
Initial List: 10 20 30 40 50
Initial Listafter insert at end: 10 20 30 40 50 20
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

48. Insertion at specific pos

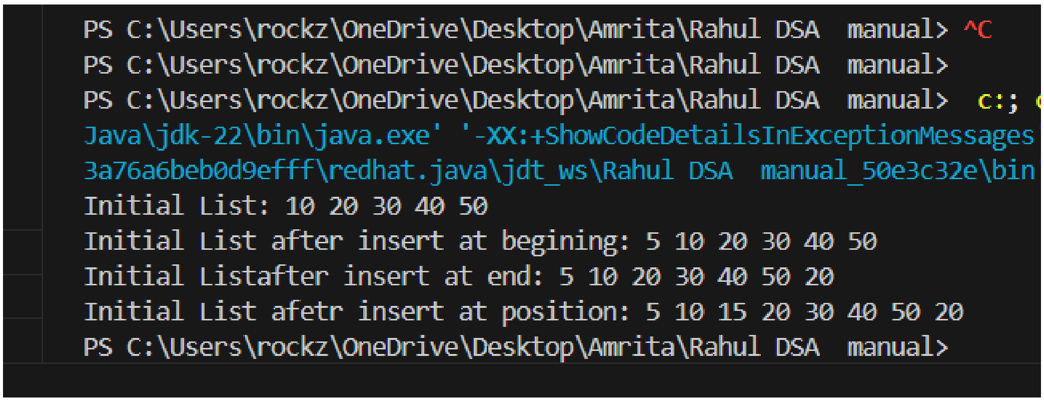
```
class CDNode

{

int data;

CDNode next;

CDNode prev;

CDNode(int value)

{

this.data=value;

this.next=null;

this.prev=null;

}

}

public class CircularDoublyLinkedList

{
```

```
private CDNode head;
private CDNode tail;

public void add(int value)
{
CDNode newNode=new CDNode(value);
if(head==null)
{
head=newNode;
tail=newNode;
head.next=head;
head.prev=head;
}else{
tail.next=newNode;
newNode.prev=tail;
tail=newNode;
tail.next=head;
head.prev=tail;
}
}
public void display()
{
if(head==null)
{
System.out.print("empty");
return;
}
CDNode temp=head;
```

```
do {
System.out.print(temp.data+" ");
temp=temp.next;
} while (temp!=head);
System.out.println();
}
public void insertatbegining(int value)
{
CDNode newNode=new CDNode(value);
if(head==null)
{
head=newNode;
tail = newNode;
newNode.next = newNode;
newNode.prev = newNode;
} else {
newNode.next = head;
newNode.prev = tail;
head.prev = newNode;
tail.next = newNode;
head = newNode;


}
}
public void insertAtEnd(int value) {
CDNode newNode = new CDNode(value);
if (head == null) {
head = newNode;
```

```
tail = newNode;
newNode.next = newNode;
newNode.prev = newNode;
} else {
newNode.next = head;
newNode.prev = tail;
tail.next = newNode;
head.prev = newNode;
tail = newNode;
}
}
public void insertAtPosition(int value, int pos) {
if (head == null || pos == 1) {
insertatbegining(value);
return;
}
CDNode newNode = new CDNode(value);
CDNode temp = head;
for(int i=1;i<pos-1;i++)
{
temp=temp.next;
}
newNode.next = temp.next;
newNode.prev = temp;
temp.next.prev = newNode;
temp.next = newNode;
if(head==tail)
{
```

```
insertAtEnd(value);
return;
}
}
public static void main(String[] args) {
CircularDoublyLinkedList cdList = new CircularDoublyLinkedList();

cdList.add(10);
cdList.add(20);
cdList.add(30);
cdList.add(40);
cdList.add(50);
System.out.print("Initial List: ");
cdList.display();
cdList.insertatbegining(5);
System.out.print("Initial List after insert at begining: ");
cdList.display();
cdList.insertAtEnd(20);
System.out.print("Initial Listafter insert at end: ");
cdList.display();
cdList.insertAtPosition(15, 3);
System.out.print("Initial List afetr insert at position: ");
cdList.display();
}
}
```



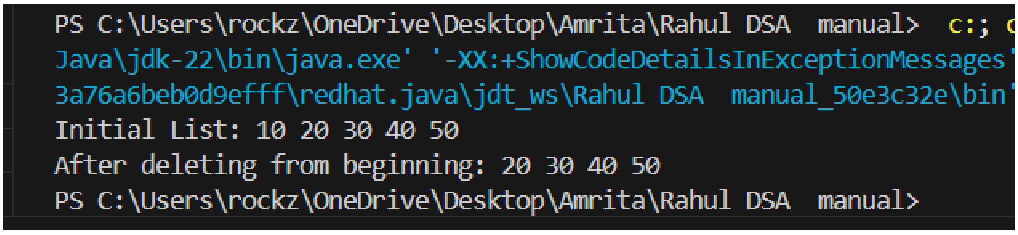
```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual> ^C
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  c:; c
Java\jdk-22\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\bin
Initial List: 10 20 30 40 50
Initial List after insert at begining: 5 10 20 30 40 50
Initial Listafter insert at end: 5 10 20 30 40 50 20
Initial List afetr insert at position: 5 10 15 20 30 40 50 20
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

49.Deletion from start

```
class CDNode

{

int data;

CDNode next;

CDNode prev;

CDNode(int value)

{

this.data=value;

this.next=null;
this.prev=null;
}
}
public class CircularDoublyLinkedList
{
private CDNode head;
private CDNode tail;

public void add(int value)
{
CDNode newNode=new CDNode(value);
if(head==null)
{
head=newNode;
tail=newNode;
head.next=head;
head.prev=head;
}else{
tail.next=newNode;
newNode.prev=tail;
tail=newNode;
tail.next=head;
head.prev=tail;
}
}
public void display()
{
if(head==null)
```

```
{
System.out.print("empty");
return;
}
CDNode temp=head;
do {
System.out.print(temp.data+" ");
temp=temp.next;
} while (temp!=head);
System.out.println();
}
public void deleteFromBeginning() {
if (head == null) {
System.out.println("List is empty!");
return;
}
if (head == tail) {
head = null;
tail = null;
return;
} else {
head = head.next;
tail.next = head;
head.prev = tail;
}
}
public static void main(String[] args) {
CircularDoublyLinkedList cdList = new CircularDoublyLinkedList();
```

```
cdList.add(10);

cdList.add(20);

cdList.add(30);

cdList.add(40);

cdList.add(50);

System.out.print("Initial List: ");

cdList.display();

cdList.deleteFromBeginning();

System.out.print("After deleting from beginning: ");

cdList.display();

}

}
```



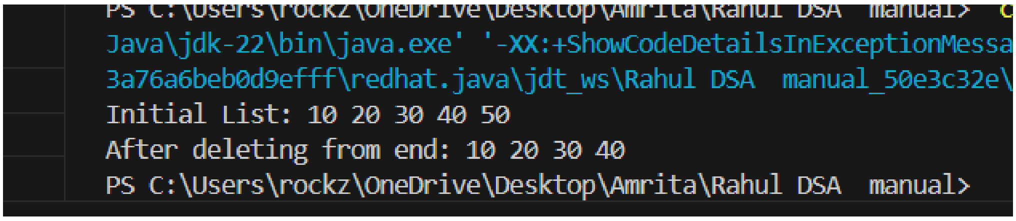
```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  c:; c
Java\jdk-22\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages'
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\bin'
Initial List: 10 20 30 40 50
After deleting from beginning: 20 30 40 50
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

50. deletion from end

```
class CDNode {
int data;
CDNode next;
CDNode prev;

CDNode(int value) {
this.data = value;
this.next = null;
this.prev = null;
}
}

public class CircularDoublyLinkedList {
private CDNode head;
private CDNode tail;

public void add(int value) {
CDNode newNode = new CDNode(value);
if (head == null) {
head = newNode;
tail = newNode;
head.next = head;
head.prev = head;
} else {
tail.next = newNode;
newNode.prev = tail;
tail = newNode;
```

```
tail.next = head;
head.prev = tail;
}
}

public void display() {
if (head == null) {
System.out.println("List is empty!");
return;
}
CDNode temp = head;
do {
System.out.print(temp.data + " ");
temp = temp.next;
} while (temp != head);
System.out.println();
}

public void deleteFromEnd() {
if (head == null) {
System.out.println("List is empty!");
return;
}
if (head == tail) {
head = null;
tail = null;
} else {
tail = tail.prev;
```

```
tail.next = head;

head.prev = tail;

}

}


public static void main(String[] args) {

CircularDoublyLinkedList cdList = new CircularDoublyLinkedList();


cdList.add(10);

cdList.add(20);

cdList.add(30);

cdList.add(40);

cdList.add(50);

System.out.print("Initial List: ");

cdList.display();

cdList.deleteFromEnd();

System.out.print("After deleting from end: ");

cdList.display();

}

}
```



```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  c
Java\jdk-22\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessa
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\
Initial List: 10 20 30 40 50
After deleting from end: 10 20 30 40
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

51. Deletion at specific position

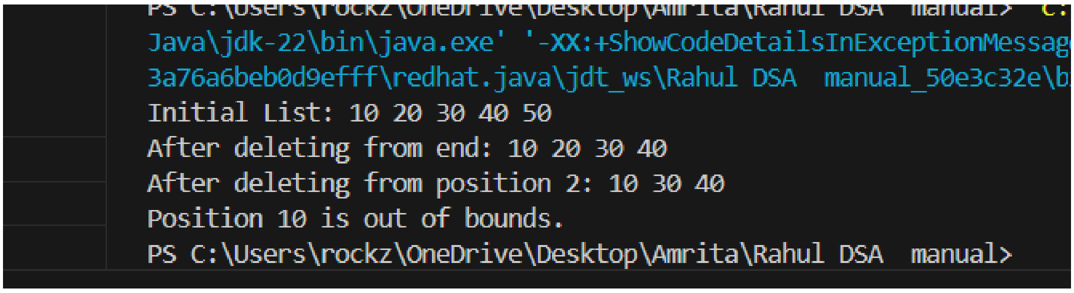
```
class CDNode {

int data;

CDNode next;

CDNode prev;


CDNode(int value) {

this.data = value;

this.next = null;

this.prev = null;

}

}


public class CircularDoublyLinkedList {

private CDNode head;

private CDNode tail;


public void add(int value) {

CDNode newNode = new CDNode(value);

if (head == null) {

head = tail = newNode;

head.next = head.prev = head;

} else {

newNode.prev = tail;

newNode.next = head;

tail.next = newNode;

head.prev = newNode;
```

```
tail = newNode;
}
}

public void deleteFromBeginning() {
if (head == null) {
System.out.println("List is empty!");
return;
}
if (head == tail) {
head = tail = null;
} else {
head = head.next;
head.prev = tail;
tail.next = head;
}
}

public void deleteFromEnd() {
if (head == null) {
System.out.println("List is empty!");
return;
}
if (head == tail) {
head = tail = null;
} else {
tail = tail.prev;
tail.next = head;
```

```
head.prev = tail;

}

}


public void deleteFromPosition(int pos) {

if (head == null) {

System.out.println("List is empty, can't delete at position " + pos);

return;

}


if (pos == 1) {

deleteFromBeginning();

return;

}


CDNode current = head;

int count = 1;


do {

if (count == pos) {

if (current == tail) {

deleteFromEnd();

} else {

current.prev.next = current.next;

current.next.prev = current.prev;

}

return;

}
```

```
current = current.next;
count++;
} while (current != head);

System.out.println("Position " + pos + " is out of bounds.");
}

public void display() {
if (head == null) {
System.out.println("List is empty!");
return;
}
CDNode temp = head;
do {
System.out.print(temp.data + " ");
temp = temp.next;
} while (temp != head);
System.out.println();
}

public static void main(String[] args) {
CircularDoublyLinkedList cdList = new CircularDoublyLinkedList();

cdList.add(10);
cdList.add(20);
cdList.add(30);
cdList.add(40);
cdList.add(50);
```

```
System.out.print("Initial List: ");

cdList.display();


cdList.deleteFromEnd();

System.out.print("After deleting from end: ");

cdList.display();


cdList.deleteFromPosition(2);

System.out.print("After deleting from position 2: ");

cdList.display();


cdList.deleteFromPosition(10); // Test out-of-bounds

}

}
```



```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  C:
Java\jdk-22\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessag
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\b
Initial List: 10 20 30 40 50
After deleting from end: 10 20 30 40
After deleting from position 2: 10 30 40
Position 10 is out of bounds.
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

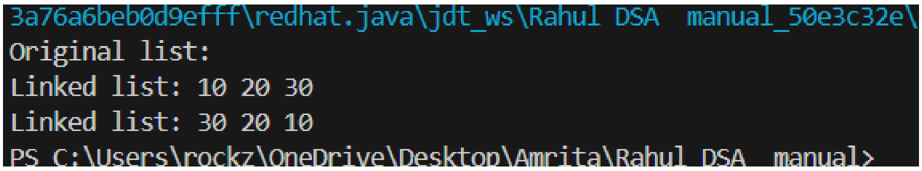
LAB_5 (28-02-25)

52. REVERSING A SLL

```
class Node {
int data;
Node next;

Node(int value) {
this.data = value;
this.next = null;
}
}

class SinglyLinkedList {
private Node head;
private Node tail;

// Add a node at the end
public void add(int value) {
Node newNode = new Node(value);
if (head == null) {
head = newNode;
tail = newNode;
} else {
tail.next = newNode;
tail = newNode;
```

```
}

}


void reverse() {

Node prev = null;

Node temp = head;

Node next = null;

while (temp != null)

{

next = temp.next;

temp.next = prev;

prev = temp;

temp = next;

}

head = prev;

}


// Display the list

public void display() {

if (head == null) {

System.out.println("Linked list is empty.");

return;

}

Node temp = head;

System.out.print("Linked list: ");

while (temp != null) {

System.out.print(temp.data + " ");

temp = temp.next;
```

```
}
System.out.println();
}
}

// Main class
public class Main {
public static void main(String[] args) {
SinglyLinkedList list = new SinglyLinkedList();

list.add(10);
list.add(20);
list.add(30);

System.out.println("Original list:");
list.display();

list.reverse();
list.display();
}
}
```



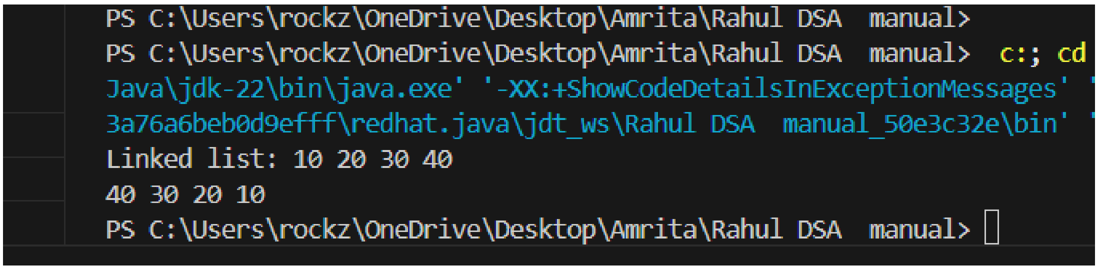
```
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\
Original list:
Linked list: 10 20 30
Linked list: 30 20 10
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

53. Reversing a DLL

```
// Node class for Doubly Linked List
class DNode {
int data;
DNode next;
DNode prev;

DNode(int value) {
this.data = value;
this.next = null;
this.prev = null;
}
}

// Doubly Linked List class
public class DoublyLinkedList {
private DNode head;
private DNode tail;

// Add node to the end
public void add(int value) {
DNode newDNode = new DNode(value);
if (head == null) {
head = newDNode;
tail = newDNode;
} else {
```

```
tail.next = newDNode;
newDNode.prev = tail;
tail = newDNode;
}
}


public void reverse()
{
if(head==null)
{
System.out.println("empty");
return;
}
DNode temp=tail;
while(temp!=null)
{
System.out.print(temp.data+" ");
temp=temp.prev;
}
System.out.println();
}

// Display the list
public void display() {
if (head == null) {
System.out.println("Linked list is empty.");
return;
```

```
}
DNode temp = head;
System.out.print("Linked list: ");
while (temp != null) {
System.out.print(temp.data + " ");
temp = temp.next;
}
System.out.println();
}

// Main method
public static void main(String[] args) {
DoublyLinkedList dlist = new DoublyLinkedList();

dlist.add(10);
dlist.add(20);
dlist.add(30);
dlist.add(40);
dlist.display();

dlist.reverse();

}
}
```



```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  c:; cd
Java\jdk-22\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages' '
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\bin' '
Linked list: 10 20 30 40
40 30 20 10
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual> 
```

54. Reversing a Circular SLL

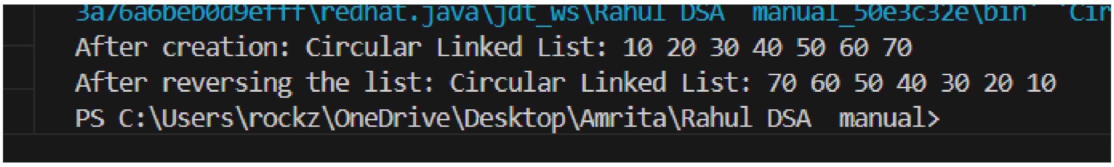
```
class CNode {
int data;
CNode next;

CNode(int value) {
this.data = value;
this.next = null;
}
}

public class CircularLinkedList {
private CNode head;
private CNode tail;

public void add(int value) {
CNode newCNode = new CNode(value);
if (head == null) {
head = newCNode;
tail = newCNode;
tail.next = head;
} else {
```

```
tail.next = newCNode;

tail = newCNode;

tail.next = head;

}

}


public void reverse() {

if (head == null || head.next == head) {

return; // no need to reverse if list is empty or has only 1 node

}


CNode prev = tail;

CNode current = head;

CNode next;


do {

next = current.next;

current.next = prev;

prev = current;

current = next;

} while (current != head);


tail = head;

head = prev;

}


public void display() {

if (head == null) {
```

```
System.out.println("List is empty.");
return;
}
CNode temp = head;
System.out.print("Circular Linked List: ");
do {
System.out.print(temp.data + " ");
temp = temp.next;
} while (temp != head);
System.out.println();
}

public static void main(String[] args) {
CircularLinkedList clist = new CircularLinkedList();
clist.add(10);
clist.add(20);
clist.add(30);
clist.add(40);
clist.add(50);
clist.add(60);
clist.add(70);

System.out.print("After creation: ");
clist.display();

clist.reverse();
System.out.print("After reversing the list: ");
clist.display();
```

}

}

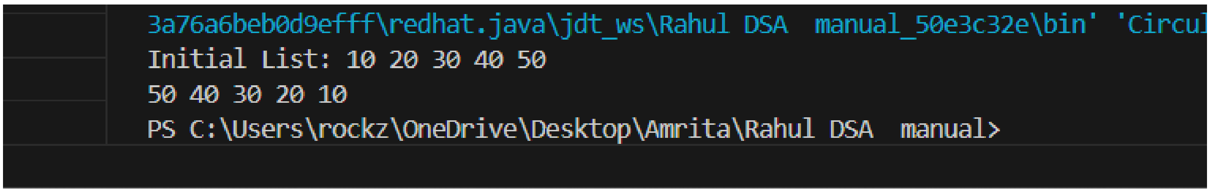


```
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\bin'  'Cir
After creation: Circular Linked List: 10 20 30 40 50 60 70
After reversing the list: Circular Linked List: 70 60 50 40 30 20 10
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

55. Reversing of Circular DLL

```
class CDNode {

int data;

CDNode next;

CDNode prev;


CDNode(int value) {

this.data = value;

this.next = null;

this.prev = null;

}

}


public class CircularDoublyLinkedList {

private CDNode head;

private CDNode tail;


public void add(int value) {

CDNode newNode = new CDNode(value);
```

```
if (head == null) {
head = tail = newNode;
head.next = head.prev = head;
} else {
newNode.prev = tail;
newNode.next = head;
tail.next = newNode;
head.prev = newNode;
tail = newNode;
}
}
public void Reverse() {
if (head == null)
{
System.out.println("List is empty.");
return;
}
CDNode temp = tail;
do {
System.out.print(temp.data + " ");
temp = temp.prev;
} while (temp != tail);
System.out.println();
}

public void display() {
if (head == null) {
System.out.println("List is empty!");
return;
}
CDNode temp = head;
do {
System.out.print(temp.data + " ");
temp = temp.next;
} while (temp != head);
System.out.println();
}

public static void main(String[] args) {
CircularDoublyLinkedList cdList = new CircularDoublyLinkedList();

cdList.add(10);
cdList.add(20);
cdList.add(30);
cdList.add(40);
cdList.add(50);

System.out.print("Initial List: ");
cdList.display();
cdList.Reverse();
}
}
```



```
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\bin' 'Circul
Initial List: 10 20 30 40 50
50 40 30 20 10
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

LAB_6 (7-03-25)

56. Stack operation in java

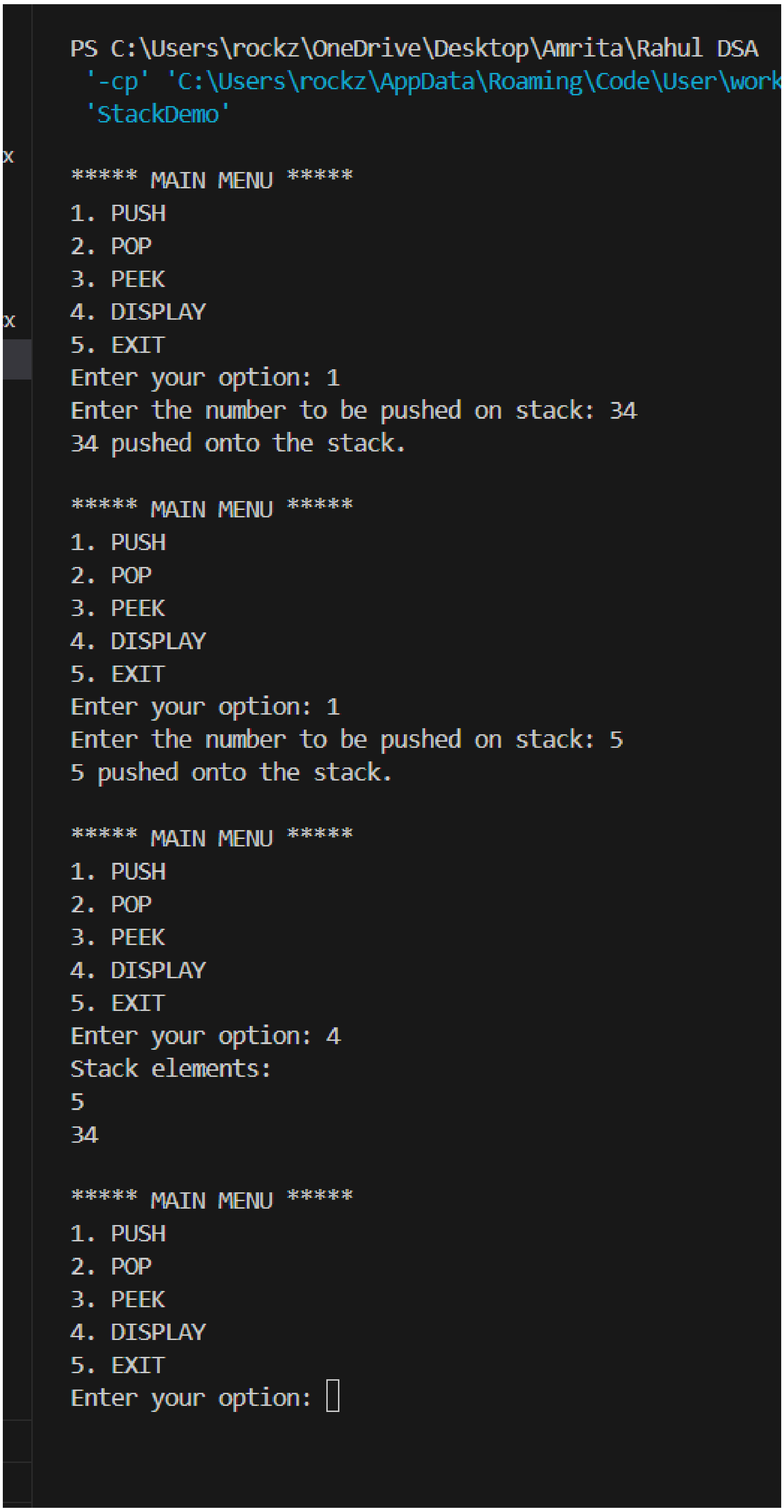
Implementation stack using array

```
import java.util.Scanner;

class Stack {
private int[] stack;
private int top;
private int max;
public Stack(int size) {
max = size;
stack = new int[max];
top = -1;
}
public void push(int val) {
if (top == max - 1) {
System.out.println("STACK OVERFLOW! Cannot push " + val);
} else {
stack[++top] = val;
System.out.println(val + " pushed onto the stack.");
}
}
```

```java
public int pop() {
if (top == -1) {
System.out.println("STACK UNDERFLOW! No elements to pop.");
return -1;
} else {
System.out.println(stack[top] + " popped from the stack.");
return stack[top--];
}
}
public int peek() {
if (top == -1) {
System.out.println("STACK IS EMPTY! No elements to peek.");
return -1;
} else {
return stack[top];
}
}
public void display() {
if (top == -1) {
System.out.println("STACK IS EMPTY!");
} else {
System.out.println("Stack elements:");
for (int i = top; i >= 0; i--) {
System.out.println(stack[i]);
}
}
}
}
```

```
public class StackDemo {
public static void main(String[] args) {
Scanner scanner = new Scanner(System.in);
Stack stack = new Stack(3);
int option, val;
do {
// Displaying menu options
System.out.println("\n***** MAIN MENU *****");
System.out.println("1. PUSH");
System.out.println("2. POP");
System.out.println("3. PEEK");
System.out.println("4. DISPLAY");
System.out.println("5. EXIT");
System.out.print("Enter your option: ");
option = scanner.nextInt();
switch (option) {
case 1:
System.out.print("Enter the number to be pushed on stack: ");
val = scanner.nextInt();
stack.push(val);
break;
case 2:
stack.pop();
break;
case 3:
val = stack.peek();
if (val != -1) {
```

```
System.out.println("The value stored at the top of the stack is: " + val);
}
break;
case 4:
stack.display();
break;
}
} while (option != 5);
scanner.close();
}
```

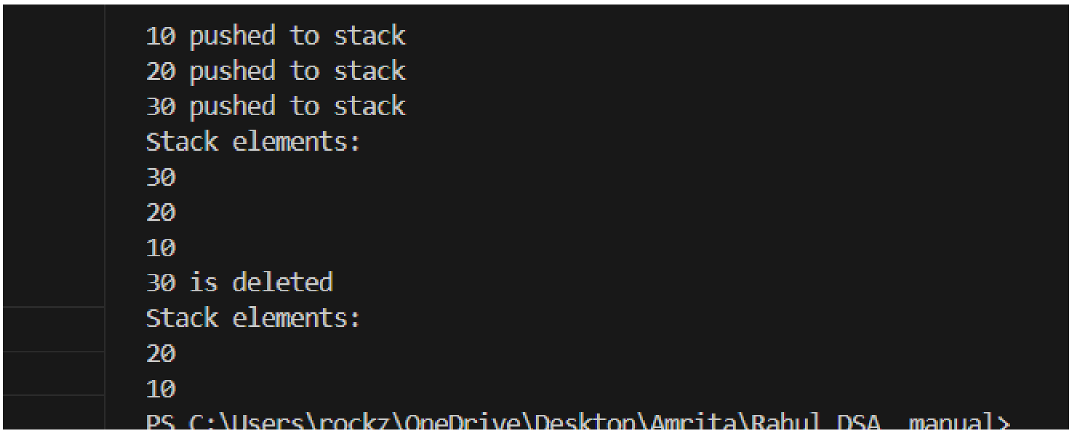


```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA
 '-cp' 'C:\Users\rockz\AppData\Roaming\Code\User\work
 'StackDemo'

***** MAIN MENU *****
1. PUSH
2. POP
3. PEEK
4. DISPLAY
5. EXIT
Enter your option: 1
Enter the number to be pushed on stack: 34
34 pushed onto the stack.

***** MAIN MENU *****
1. PUSH
2. POP
3. PEEK
4. DISPLAY
5. EXIT
Enter your option: 1
Enter the number to be pushed on stack: 5
5 pushed onto the stack.

***** MAIN MENU *****
1. PUSH
2. POP
3. PEEK
4. DISPLAY
5. EXIT
Enter your option: 4
Stack elements:
5
34

***** MAIN MENU *****
1. PUSH
2. POP
3. PEEK
4. DISPLAY
5. EXIT
Enter your option: 
```

57. Implementation of stack using linked list

```
class StackNode {
int data;
StackNode next;

public StackNode(int data) {
this.data = data;
this.next = null;
}
}

public class Stack {
private StackNode top;

public Stack() {
this.top = null;
}

public void push(int ele) {
StackNode newNode = new StackNode(ele);
newNode.next = top;
top = newNode;
System.out.println(ele + " pushed to stack");
}

public int pop() {
if (top == null) {
```

```
System.out.println("STACK IS EMPTY");
return -1;
}
int popped = top.data;
top = top.next;
System.out.println(popped + " is deleted");
return popped;
}

public void display() {
if (top == null) {
System.out.println("STACK IS EMPTY");
return;
}
StackNode temp = top;
System.out.println("Stack elements:");
while (temp != null) {
System.out.println(temp.data);
temp = temp.next;
}
}

public static void main(String[] args) {
Stack stack = new Stack();
stack.push(10);
stack.push(20);
stack.push(30);
stack.display();
stack.pop();

stack.display();

}

}
```



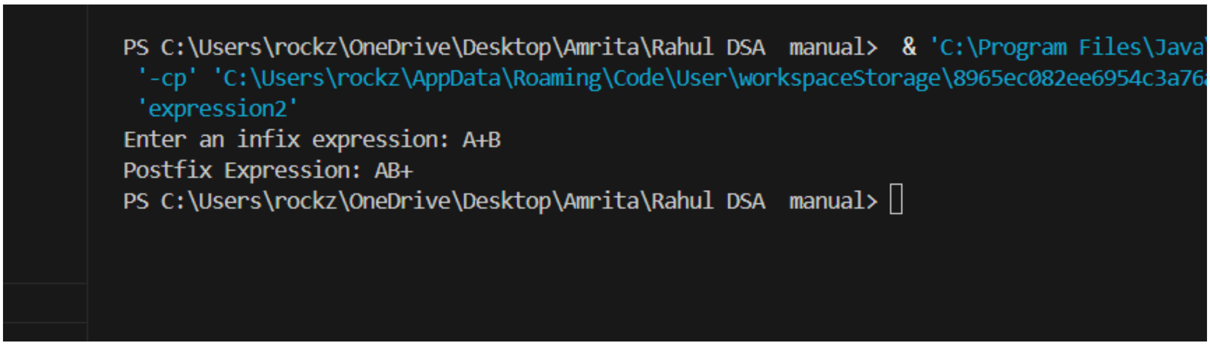
```
10 pushed to stack
20 pushed to stack
30 pushed to stack
Stack elements:
30
20
10
30 is deleted
Stack elements:
20
10
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

58. Infix to Postfix conversion

```
import java.util.Scanner;
import java.util.Stack;

public class expression2 {
static int getPrecedence(char ch) {
if (ch == '+' || ch == '-') return 1;
if (ch == '*' || ch == '/' || ch == '%') return 2;
if (ch == '^') return 3;
return -1;
}

static String convertToPostfix(String infix) {
Stack<String> postfixStack = new Stack<>();
Stack<Character> operatorStack = new Stack<>();

int i = 0;
while (i < infix.length()) {
char ch = infix.charAt(i);

if (Character.isDigit(ch)) {
String num = "";
while (i < infix.length() && Character.isDigit(infix.charAt(i))) {
num += infix.charAt(i);
i++;
}
postfixStack.push(num);
continue;
```

```
}

else if (Character.isLetter(ch)) {
postfixStack.push(String.valueOf(ch));
}

else if (ch == '(') {
operatorStack.push(ch);
}
else if (ch == ')') {
while (!operatorStack.isEmpty() && operatorStack.peek() != '(') {
postfixStack.push(String.valueOf(operatorStack.pop()));
}
operatorStack.pop();
}
else {
while (!operatorStack.isEmpty() && getPrecedence(ch) <=
getPrecedence(operatorStack.peek()) && operatorStack.peek() != '(') {
postfixStack.push(String.valueOf(operatorStack.pop()));
}
operatorStack.push(ch);
}
i++;
}

while (!operatorStack.isEmpty()) {
postfixStack.push(String.valueOf(operatorStack.pop()));
}
```

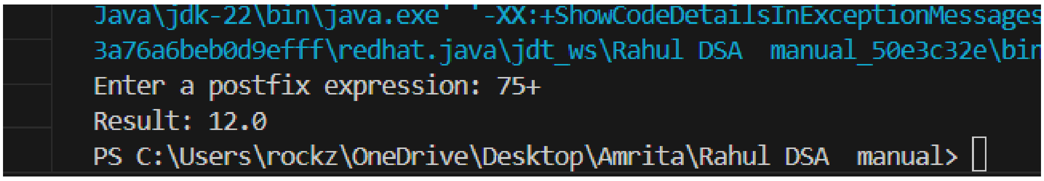
```
Stack<String> reversedStack = new Stack<>();
while (!postfixStack.isEmpty()) {
reversedStack.push(postfixStack.pop());
}

String result = "";
while (!reversedStack.isEmpty()) {
result += reversedStack.pop() ;
}

return result;
}

public static void main(String[] args) {
Scanner scanner = new Scanner(System.in);

System.out.print("Enter an infix expression: ");
String infix = scanner.nextLine();
String postfix = convertToPostfix(infix);
System.out.println("Postfix Expression: " + postfix);
scanner.close();
}
}
```



```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  & 'C:\Program Files\Java
 '-cp' 'C:\Users\rockz\AppData\Roaming\Code\User\workspaceStorage\8965ec082ee6954c3a76
 'expression2'
Enter an infix expression: A+B
Postfix Expression: AB+
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual> 
```

59. Postfix Expression Evaluation code

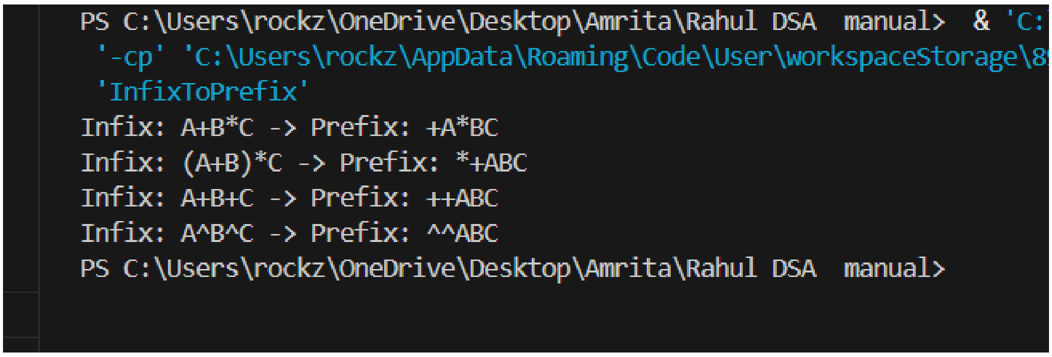
```
import java.util.Stack;
import java.util.Scanner;

public class Evaluatepostfix {

public static double evaluatePostfix(String postfix) {
Stack<Double> stack = new Stack<>();
for (int i = 0; i < postfix.length(); i++) {
char ch = postfix.charAt(i);

if (Character.isDigit(ch)) {
stack.push((double)(ch - '0'));
}
else {
double operand2 = stack.pop();
double operand1 = stack.pop();

switch (ch) {
case '+': stack.push(operand1 + operand2); break;
case '-': stack.push(operand1 - operand2); break;
case '*': stack.push(operand1 * operand2); break;
case '/': stack.push(operand1 / operand2); break;
case '%': stack.push(operand1 % operand2); break;
case '^': stack.push(Math.pow(operand1, operand2)); break;
default: throw new IllegalArgumentException("Invalid operator: " + ch);
}
}
}

return stack.pop();
}

public static void main(String[] args) {
Scanner scanner = new Scanner(System.in);

System.out.print("Enter a postfix expression: ");
String postfix = scanner.nextLine();
double result = evaluatePostfix(postfix);
System.out.println("Result: " + result);

scanner.close();
}
}
```



```
Java\jdk-22\bin\java.exe' '-XX:+ShowCodeDetailsInExceptionMessages
3a76a6beb0d9efff\redhat.java\jdt_ws\Rahul DSA  manual_50e3c32e\bin
Enter a postfix expression: 75+
Result: 12.0
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual> 
```

60.Infix to Prefix Expression

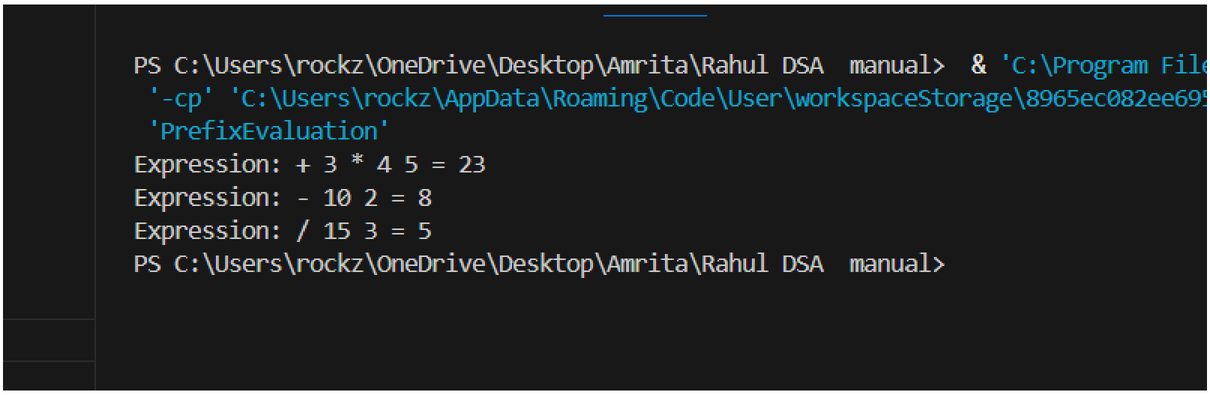
```
import java.util.Stack;
public class InfixToPrefix {
public static String infixToPrefix(String infix) {
Stack<Character> stack = new Stack<>();
StringBuilder prefix = new StringBuilder();

for (int i = infix.length() - 1; i >= 0; i--) {
char ch = infix.charAt(i);
if (Character.isLetterOrDigit(ch)) {
prefix.append(ch);
} else if (ch == ')') {
stack.push(ch);
} else if (ch == '(') {
while (stack.peek() != ')') {
prefix.append(stack.pop());
}
stack.pop();
} else {
while (!stack.isEmpty() && precedence(ch) < precedence(stack.peek())) {
prefix.append(stack.pop());
}
stack.push(ch);
}
}

while (!stack.isEmpty()) {
prefix.append(stack.pop());
}

return prefix.reverse().toString();
}

private static int precedence(char ch) {
switch (ch) {
case '+':
case '-':
return 1;
case '*':
case '/':
return 2;
case '^':
return 3;
default:
return 0;
}
}
}
```



```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  & 'C:
 '-cp' 'C:\Users\rockz\AppData\Roaming\Code\User\workspaceStorage\8
 'InfixToPrefix'
Infix: A+B*C -> Prefix: +A*BC
Infix: (A+B)*C -> Prefix: *+ABC
Infix: A+B+C -> Prefix: ++ABC
Infix: A^B^C -> Prefix: ^^ABC
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

61. Prefix Evaluation Code

```
import java.util.Stack;


public class PrefixEvaluation {
public static int evaluatePrefix(String prefix) {
Stack<Integer> stack = new Stack<>();


for (int i = prefix.length() - 1; i >= 0; i--) {
char ch = prefix.charAt(i);
if (Character.isDigit(ch)) {
stack.push(ch - '0');
} else {
int a = stack.pop();
int b = stack.pop();
switch (ch) {
case '+':
stack.push(a + b);
break;
case '-':
stack.push(a - b);
break;
case '*':
stack.push(a * b);
break;

case '/':

stack.push(a / b);

break;

}

}

}


return stack.pop();

}

}
```



```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  & 'C:\Program File
 '-cp'  'C:\Users\rockz\AppData\Roaming\Code\User\workspaceStorage\8965ec082ee695
 'PrefixEvaluation'
Expression: + 3 * 4 5 = 23
Expression: - 10 2 = 8
Expression: / 15 3 = 5
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

62. ALL in one code (infix,postfix,prefix)

```
import java.util.Stack;

public class ExpressionConverterEvaluator {

// Infix to Postfix Conversion
public static String infixToPostfix(String infix) {
Stack<Character> stack = new Stack<>();
StringBuilder postfix = new StringBuilder();

for (char ch : infix.toCharArray()) {
if (Character.isLetterOrDigit(ch)) {
postfix.append(ch);
} else if (ch == '(') {
stack.push(ch);
} else if (ch == ')') {
while (stack.peek() != '(') {
postfix.append(stack.pop());
}
stack.pop();
} else {
while (!stack.isEmpty() && precedence(ch) <= precedence(stack.peek())) {
postfix.append(stack.pop());
}
stack.push(ch);
}
}
```

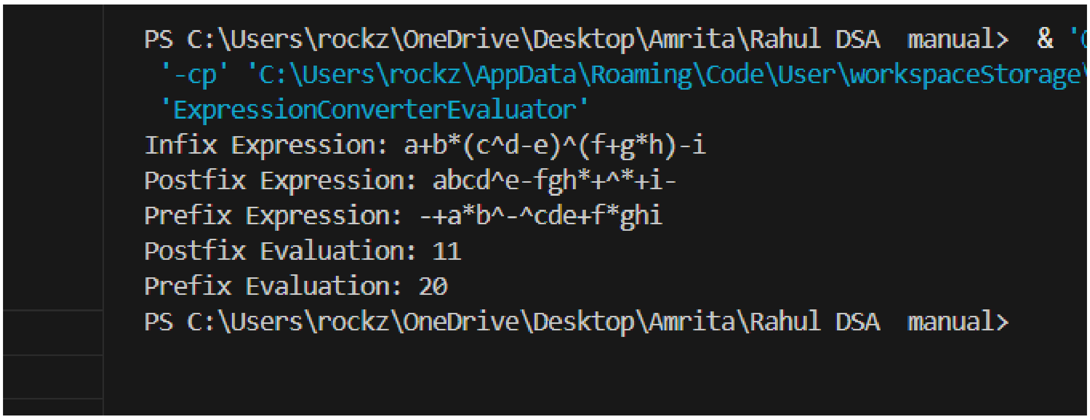
```
while (!stack.isEmpty()) {
postfix.append(stack.pop());
}

return postfix.toString();
}

// Infix to Prefix Conversion
public static String infixToPrefix(String infix) {
Stack<Character> stack = new Stack<>();
StringBuilder prefix = new StringBuilder();

for (int i = infix.length() - 1; i >= 0; i--) {
char ch = infix.charAt(i);
if (Character.isLetterOrDigit(ch)) {
prefix.append(ch);
} else if (ch == ')') {
stack.push(ch);
} else if (ch == '(') {
while (stack.peek() != ')') {
prefix.append(stack.pop());
}
stack.pop();
} else {
while (!stack.isEmpty() && precedence(ch) < precedence(stack.peek())) {
prefix.append(stack.pop());
}
stack.push(ch);
```

```
}

}


while (!stack.isEmpty()) {

prefix.append(stack.pop());

}


return prefix.reverse().toString();

}


// Postfix Expression Evaluation

public static int evaluatePostfix(String postfix) {

Stack<Integer> stack = new Stack<>();


for (char ch : postfix.toCharArray()) {

if (Character.isDigit(ch)) {

stack.push(ch - '0');

} else {

int b = stack.pop();

int a = stack.pop();

switch (ch) {

case '+':

stack.push(a + b);

break;

case '-':

stack.push(a - b);

break;

case '*':
```

```
stack.push(a * b);
break;
case '/':
stack.push(a / b);
break;
}
}
}

return stack.pop();
}

// Prefix Expression Evaluation
public static int evaluatePrefix(String prefix) {
Stack<Integer> stack = new Stack<>();

for (int i = prefix.length() - 1; i >= 0; i--) {
char ch = prefix.charAt(i);
if (Character.isDigit(ch)) {
stack.push(ch - '0');
} else {
int a = stack.pop();
int b = stack.pop();
switch (ch) {
case '+':
stack.push(a + b);
break;
case '-':
```

```
stack.push(a - b);
break;
case '*':
stack.push(a * b);
break;
case '/':
stack.push(a / b);
break;
}
}
}

return stack.pop();
}

// Helper method to determine operator precedence
private static int precedence(char ch) {
switch (ch) {
case '+':
case '-':
return 1;
case '*':
case '/':
return 2;
case '^':
return 3;
default:
return 0;
```

```
}

}


public static void main(String[] args) {

String infixExpression = "a+b*(c^d-e)^(f+g*h)-i";

String postfixExpression = infixToPostfix(infixExpression);

String prefixExpression = infixToPrefix(infixExpression);


System.out.println("Infix Expression: " + infixExpression);

System.out.println("Postfix Expression: " + postfixExpression);

System.out.println("Prefix Expression: " + prefixExpression);


// Example evaluation (assuming single-digit numbers for simplicity)

String postfixExample = "23*5+"; // Equivalent to (2*3)+5

String prefixExample = "*+234"; // Equivalent to (2+(3*4))


System.out.println("Postfix Evaluation: " + evaluatePostfix(postfixExample));

System.out.println("Prefix Evaluation: " + evaluatePrefix(prefixExample));

}

}
```



```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  & '
 '-cp'  'C:\Users\rockz\AppData\Roaming\Code\User\workspaceStorage\
 'ExpressionConverterEvaluator'
Infix Expression: a+b*(c^d-e)^(f+g*h)-i
Postfix Expression: abcd^e-fgh*+^*+i-
Prefix Expression: -+a*b^-^cde+f*ghi
Postfix Evaluation: 11
Prefix Evaluation: 20
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

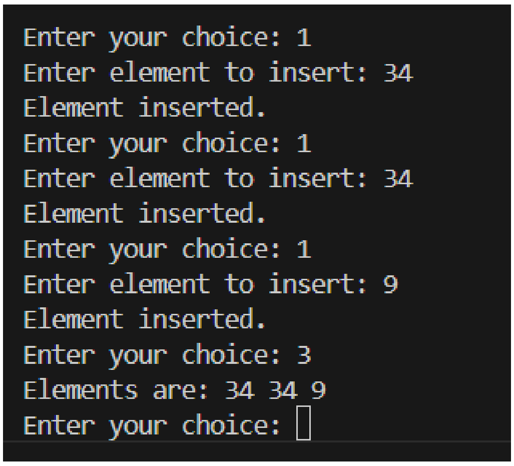
LAB_7 (12-03-25)

63. Queue Using Array

```
import java.util.Scanner;

class QueueUsingArray {
int[] ar = new int[10];
int n = 10;
int front = -1;
int rear = -1;

void enqueue(int item) {
if (rear == n - 1) {
System.out.println("Overflow!");
return;
}
if (front == -1 && rear == -1) {
front = 0;
rear = 0;
} else {
rear++;
}
ar[rear] = item;
System.out.println("Element inserted.");
}

void dequeue() {
if (front == -1 || front > rear) {
```

```
System.out.println("Underflow!");

return;

}

System.out.println("Element deleted from queue is: " + ar[front]);

if (front == rear) {

front = -1;

rear = -1;

} else {

front++;

}

}


void display() {

if (front == -1 || front > rear) {

System.out.println("Queue is empty.");

return;

}

System.out.print("Elements are: ");

for (int i = front; i <= rear; i++) {

System.out.print(ar[i] + " ");

}

System.out.println();

}


public static void main(String[] args) {

Scanner sc = new Scanner(System.in);

QueueUsingArray q = new QueueUsingArray();
```

```
System.out.println("Queue Operations:");
System.out.println("1: Enqueue");
System.out.println("2: Dequeue");
System.out.println("3: Display");
System.out.println("4: Exit");

int choice;
do {
System.out.print("Enter your choice: ");
choice = sc.nextInt();

switch (choice) {
case 1:
System.out.print("Enter element to insert: ");
int item = sc.nextInt();
q.enqueue(item);
break;
case 2:
q.dequeue();
break;
case 3:
q.display();
break;
case 4:
System.out.println("Exiting...");
break;
default:
System.out.println("Invalid choice. Try again.");
}

} while (choice != 4);

sc.close();
}
}
```

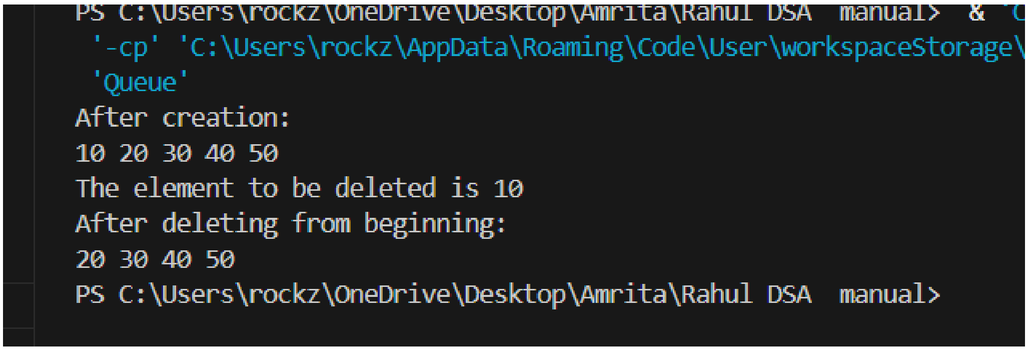


```
Enter your choice: 1
Enter element to insert: 34
Element inserted.
Enter your choice: 1
Enter element to insert: 34
Element inserted.
Enter your choice: 1
Enter element to insert: 9
Element inserted.
Enter your choice: 3
Elements are: 34 34 9
Enter your choice: 
```

64. Queue using linked list

```
class Node {
int data;
Node next;

Node(int data) {
this.data = data;
this.next = null;
}
}

public class Queue {
private Node front;
private Node rear;

public void EnQueue(int value) {
Node newNode = new Node(value);
if (front == null) {
front = newNode;
rear = newNode;
} else {
rear.next = newNode;
rear = newNode;
}
}
```

```
public void DeQueue() {
if (front == null) {
System.out.println("Queue is empty, can't delete at beginning. (Underflow)");
return;
}

System.out.println("The element to be deleted is " + front.data);

if (front == rear) {
front = null;
rear = null;
} else {
front = front.next;
}
}

public void display() {
if (front == null) {
System.out.println("Queue is empty!");
return;
}

Node temp = front;
while (temp != null) {
System.out.print(temp.data + " ");
temp = temp.next;
}
System.out.println();
}

public static void main(String[] args) {

Queue queue = new Queue();

queue.EnQueue(10);

queue.EnQueue(20);

queue.EnQueue(30);

queue.EnQueue(40);

queue.EnQueue(50);

System.out.println("After creation:");

queue.display();

queue.DeQueue();

System.out.println("After deleting from beginning:");

queue.display();

}

}
```



```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  & 'C
 '-cp' 'C:\Users\rockz\AppData\Roaming\Code\User\workspaceStorage\
 'Queue'
After creation:
10 20 30 40 50
The element to be deleted is 10
After deleting from beginning:
20 30 40 50
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

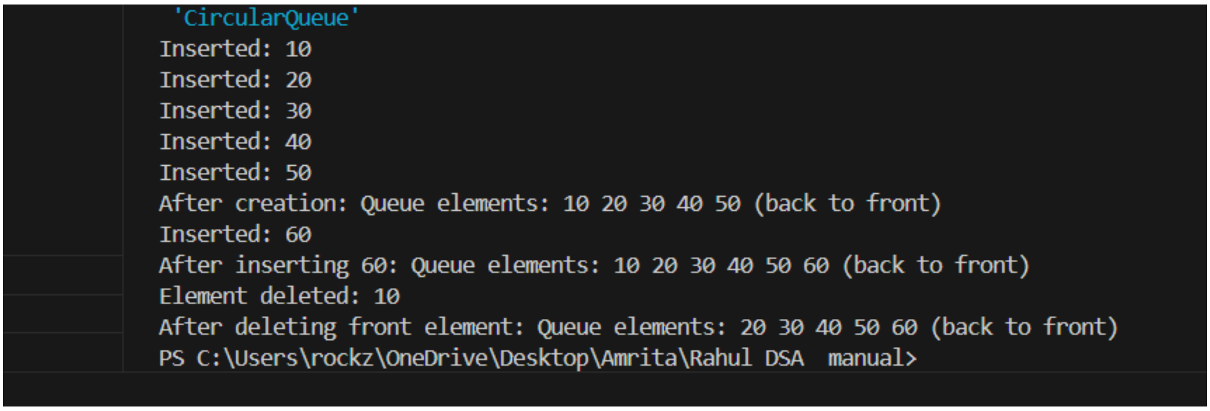
65. Circular queue using Array

Circular queue using Linked list

```
class CNode {
int data;
CNode next;

CNode(int value) {
this.data = value;
this.next = null;
}
}

public class CircularQueue {
private CNode front, rear;

public void enqueue(int value) {
CNode newNode = new CNode(value);
if (front == null) {
front = rear = newNode;
rear.next = front;
} else {
rear.next = newNode;
rear = newNode;
rear.next = front;
}
System.out.println("Inserted: " + value);
```

```
}

public void dequeue() {
if (front == null) {
System.out.println("Queue is empty, can't delete.");
return;
}

System.out.println("Element deleted: " + front.data);

if (front == rear) {
front = rear = null;
} else {
front = front.next;
rear.next = front;
}
}

public void display() {
if (front == null) {
System.out.println("Queue is empty.");
return;
}

System.out.print("Queue elements: ");
CNode temp = front;
do {
System.out.print(temp.data + " ");
```

```java
temp = temp.next;
} while (temp != front);
System.out.println("(back to front)");
}

public static void main(String[] args) {
CircularQueue queue = new CircularQueue();

queue.enqueue(10);
queue.enqueue(20);
queue.enqueue(30);
queue.enqueue(40);
queue.enqueue(50);

System.out.print("After creation: ");
queue.display();

queue.enqueue(60);
System.out.print("After inserting 60: ");
queue.display();

queue.dequeue();
System.out.print("After deleting front element: ");
queue.display();
}
}
```



```
 'CircularQueue'
Inserted: 10
Inserted: 20
Inserted: 30
Inserted: 40
Inserted: 50
After creation: Queue elements: 10 20 30 40 50 (back to front)
Inserted: 60
After inserting 60: Queue elements: 10 20 30 40 50 60 (back to front)
Element deleted: 10
After deleting front element: Queue elements: 20 30 40 50 60 (back to front)
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

LAB_8 (28-03-25)

66. Priority Queue using Array

class PNode {

int data, priority;

PNode next;

PNode(int data, int priority) {

this.data = data;

this.priority = priority;

this.next = null;

}

}

public class PriorityQueue {

private PNode front;

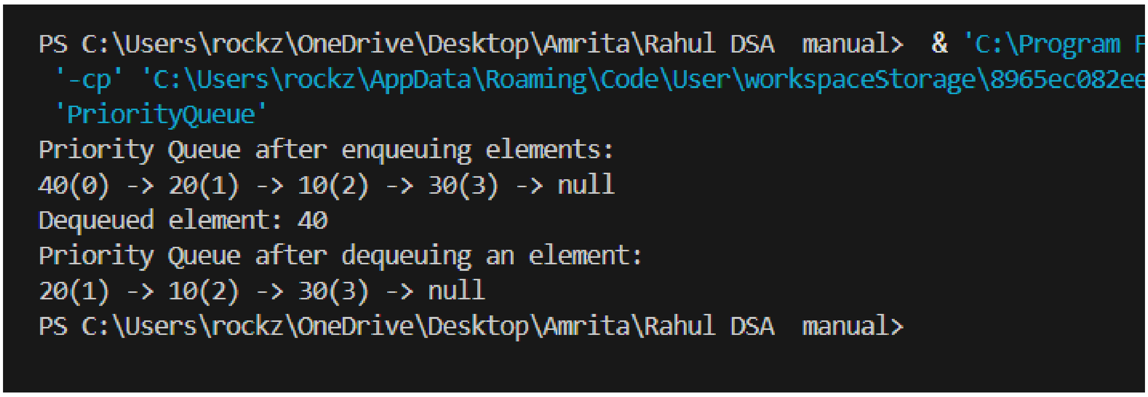
public PriorityQueue() {

front = null;

}

```
public void enqueue(int data, int priority) {

PNode newNode = new PNode(data, priority);

if (front == null || priority < front.priority) {

newNode.next = front;

front = newNode;

} else {

PNode temp = front;

while (temp.next != null && temp.next.priority <= priority) {

temp = temp.next;

}

newNode.next = temp.next;

temp.next = newNode;

}

}


public int dequeue() {

if (isEmpty()) {

System.out.println("Priority Queue is empty!");

return -1;

}

int data = front.data;

front = front.next;

return data;

}


public void display() {

if (isEmpty()) {

System.out.println("Priority Queue is empty!");
return;
}
PNode temp = front;
while (temp != null) {
System.out.print(temp.data + "(" + temp.priority + ") -> ");
temp = temp.next;
}
System.out.println("null");
}

public boolean isEmpty() {
return front == null;
}

public static void main(String[] args) {
PriorityQueue pq = new PriorityQueue();
pq.enqueue(10, 2);
pq.enqueue(20, 1);
pq.enqueue(30, 3);
pq.enqueue(40, 0);

System.out.println("Priority Queue after enqueuing elements:");
pq.display();

System.out.println("Dequeued element: " + pq.dequeue());
System.out.println("Priority Queue after dequeuing an element:");
pq.display();
}
```

}



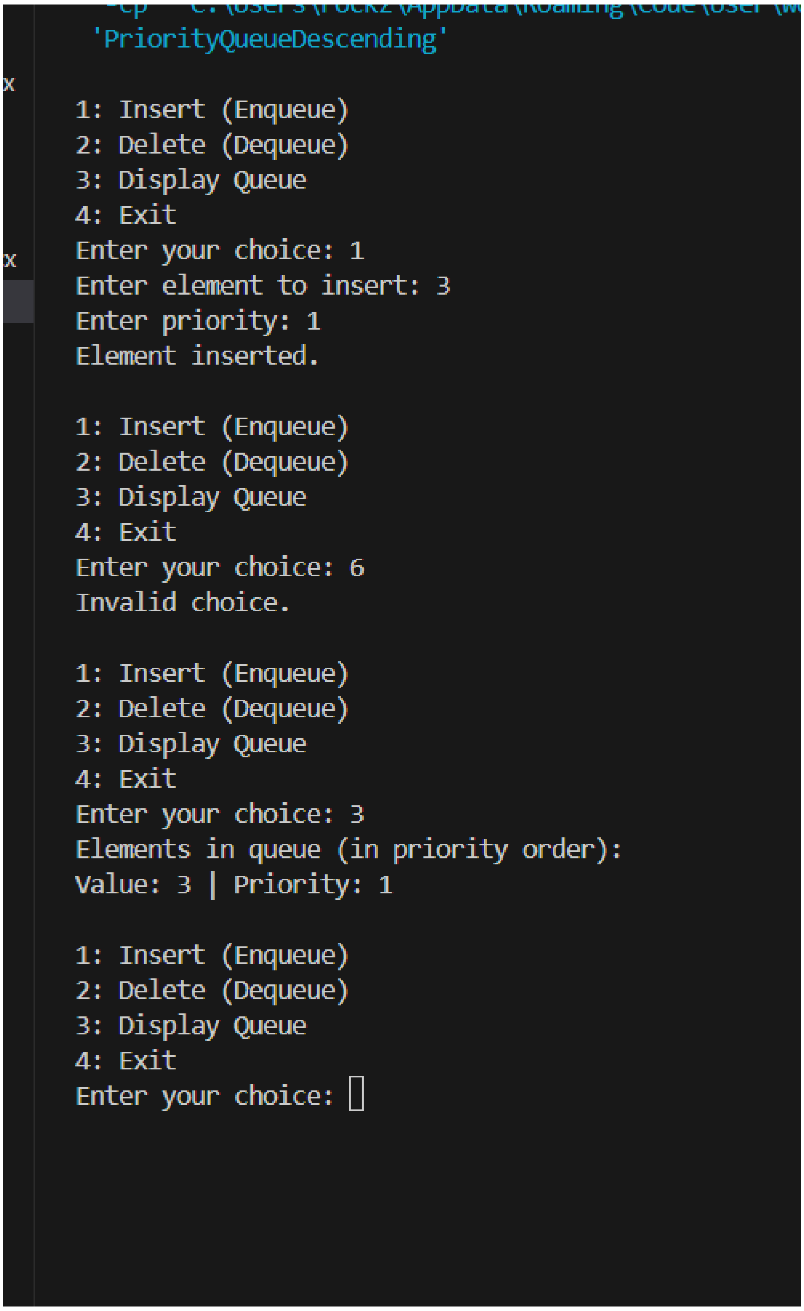
```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>  & 'C:\Program F
 '-cp' 'C:\Users\rockz\AppData\Roaming\Code\User\workspaceStorage\8965ec082ee
 'PriorityQueue'
Priority Queue after enqueuing elements:
40(0) -> 20(1) -> 10(2) -> 30(3) -> null
Dequeued element: 40
Priority Queue after dequeuing an element:
20(1) -> 10(2) -> 30(3) -> null
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Rahul DSA  manual>
```

67. Code for Priority Queue Descending

```
import java.util.Scanner;

class Node {
int data;
int priority;
Node next;

Node(int data, int priority) {
this.data = data;
this.priority = priority;
this.next = null;
}
}
```

```
public class PriorityQueueDescending {
static Node front = null;

static void enqueue(int data, int priority) {
Node newNode = new Node(data, priority);
if (front == null || priority > front.priority) {
newNode.next = front;
front = newNode;
} else {
Node temp = front;
while (temp.next != null && temp.next.priority >= priority) {
temp = temp.next;
}
newNode.next = temp.next;
temp.next = newNode;
}
System.out.println("Element inserted.");
}

static void dequeue() {
if (front == null) {
System.out.println("Underflow! Queue is empty.");
return;
}
System.out.println("Element deleted from queue is: " + front.data);
front = front.next;
}
```

```
static void display() {
if (front == null) {
System.out.println("Queue is empty.");
return;
}
System.out.println("Elements in queue (in priority order):");
Node temp = front;
while (temp != null) {
System.out.println("Value: " + temp.data + " | Priority: " + temp.priority);
temp = temp.next;
}
}

public static void main(String[] args) {
Scanner sc = new Scanner(System.in);
int ch;
do {
System.out.println("\n1: Insert (Enqueue)");
System.out.println("2: Delete (Dequeue)");
System.out.println("3: Display Queue");
System.out.println("4: Exit");
System.out.print("Enter your choice: ");
ch = sc.nextInt();
switch (ch) {
case 1:
System.out.print("Enter element to insert: ");
int data = sc.nextInt();
System.out.print("Enter priority: ");

int priority = sc.nextInt();

enqueue(data, priority);

break;

case 2:

dequeue();

break;

case 3:

display();

break;

case 4:

System.out.println("Exiting...");

break;

default:

System.out.println("Invalid choice.");

}

} while (ch != 4);

sc.close();

}

}
```



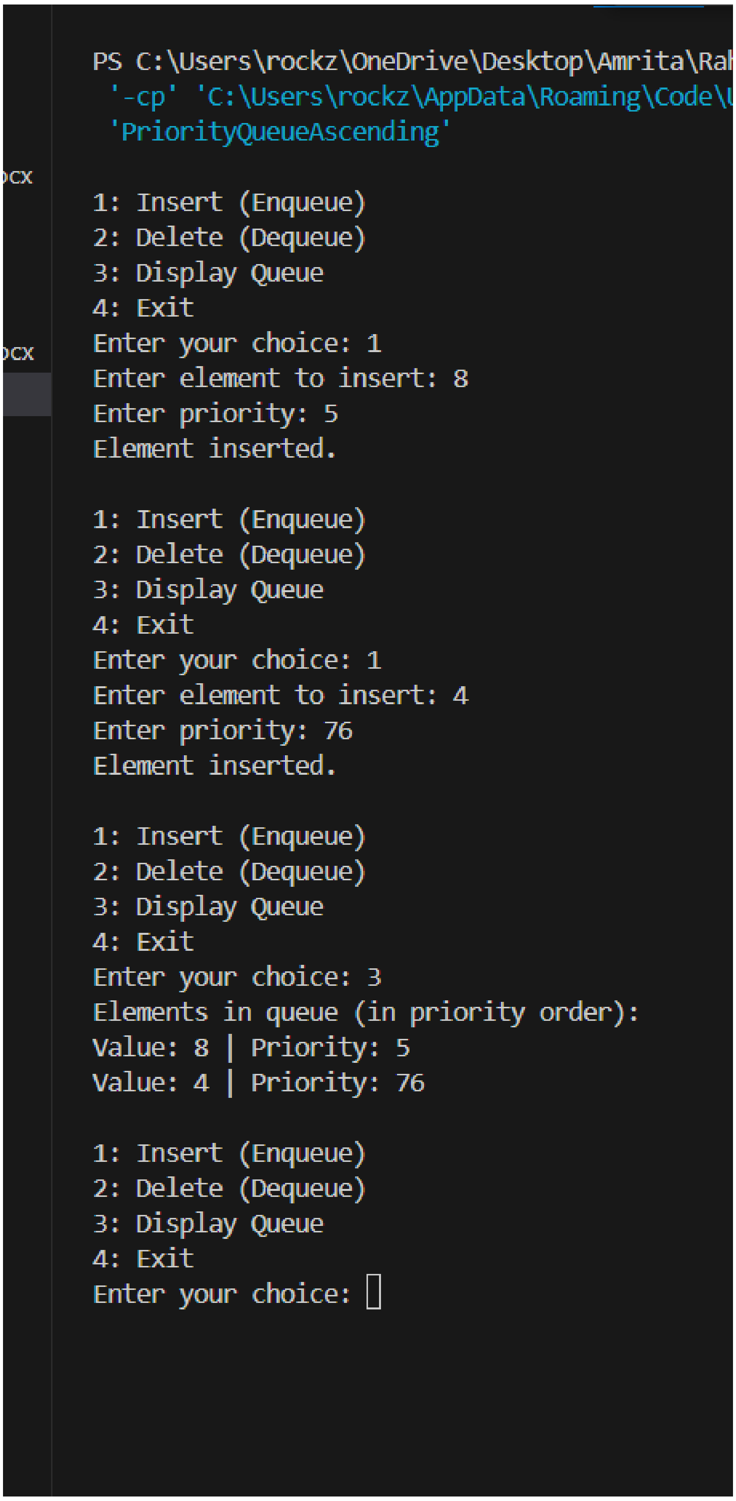
```
 -cp 'C:\Users\rock2\AppData\Roaming\Code\User\wo
  'PriorityQueueDescending'

1: Insert (Enqueue)
2: Delete (Dequeue)
3: Display Queue
4: Exit
Enter your choice: 1
Enter element to insert: 3
Enter priority: 1
Element inserted.

1: Insert (Enqueue)
2: Delete (Dequeue)
3: Display Queue
4: Exit
Enter your choice: 6
Invalid choice.

1: Insert (Enqueue)
2: Delete (Dequeue)
3: Display Queue
4: Exit
Enter your choice: 3
Elements in queue (in priority order):
Value: 3 | Priority: 1

1: Insert (Enqueue)
2: Delete (Dequeue)
3: Display Queue
4: Exit
Enter your choice: 
```

68. Ascending Priority Queue

```
import java.util.Scanner;

class Node {
int data;
int priority;
Node next;

Node(int data, int priority) {
this.data = data;
this.priority = priority;
this.next = null;
}
}

public class PriorityQueueAscending {
static Node front = null;

static void enqueue(int data, int priority) {
Node newNode = new Node(data, priority);
if (front == null || priority < front.priority) {
newNode.next = front;
front = newNode;
} else {
Node temp = front;
while (temp.next != null && temp.next.priority <= priority) {
temp = temp.next;
}
newNode.next = temp.next;
temp.next = newNode;
}
System.out.println("Element inserted.");
}

static void dequeue() {
if (front == null) {
System.out.println("Underflow! Queue is empty.");
return;
}
System.out.println("Element deleted from queue is: " + front.data);
front = front.next;
}

static void display() {
if (front == null) {
System.out.println("Queue is empty.");
return;
}
System.out.println("Elements in queue (in priority order):");
Node temp = front;
while (temp != null) {
System.out.println("Value: " + temp.data + " | Priority: " + temp.priority);
temp = temp.next;
}
}
```

```
public static void main(String[] args) {

Scanner sc = new Scanner(System.in);

int ch;

do {

System.out.println("\n1: Insert (Enqueue)");

System.out.println("2: Delete (Dequeue)");

System.out.println("3: Display Queue");

System.out.println("4: Exit");

System.out.print("Enter your choice: ");

ch = sc.nextInt();

switch (ch) {

case 1:

System.out.print("Enter element to insert: ");

int data = sc.nextInt();

System.out.print("Enter priority: ");

int priority = sc.nextInt();

enqueue(data, priority);

break;

case 2:

dequeue();

break;

case 3:

display();

break;

case 4:

System.out.println("Exiting...");

break;

default:
```

```
System.out.println("Invalid choice.");

}

} while (ch != 4);

sc.close();

}

}
```



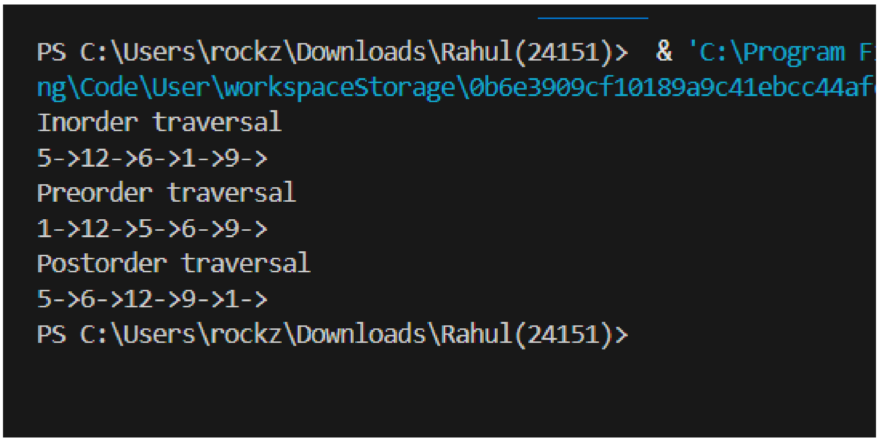
```
PS C:\Users\rockz\OneDrive\Desktop\Amrita\Ra
 '-cp' 'C:\Users\rockz\AppData\Roaming\Code\
 'PriorityQueueAscending'

1: Insert (Enqueue)
2: Delete (Dequeue)
3: Display Queue
4: Exit
Enter your choice: 1
Enter element to insert: 8
Enter priority: 5
Element inserted.

1: Insert (Enqueue)
2: Delete (Dequeue)
3: Display Queue
4: Exit
Enter your choice: 1
Enter element to insert: 4
Enter priority: 76
Element inserted.

1: Insert (Enqueue)
2: Delete (Dequeue)
3: Display Queue
4: Exit
Enter your choice: 3
Elements in queue (in priority order):
Value: 8 | Priority: 5
Value: 4 | Priority: 76

1: Insert (Enqueue)
2: Delete (Dequeue)
3: Display Queue
4: Exit
Enter your choice:
```

LAB_9 (4-4-25)

69. binary tree using array

```
class BinaryTreeArray
{
int[] tree;
int size;
public BinaryTreeArray(int capacity)
{
tree = new int[capacity];
size = 0;
}
public void add(int value)
{
if (size < tree.length)
{
tree[size] = value;
size++;
}
else
{
System.out.println("Tree is full");
}
}
public void inorder(int index)
{
if (index >= size) return;
inorder(2 * index + 1);
System.out.print(tree[index] + "->");
inorder(2 * index + 2);
}
public void preorder(int index)
{
if (index >= size) return;
System.out.print(tree[index] + "->");
preorder(2 * index + 1);
preorder(2 * index + 2);
}
public void postorder(int index)
{
if (index >= size) return;
postorder(2 * index + 1);
postorder(2 * index + 2);
System.out.print(tree[index] + "->");
}
```

```
public static void main(String[] args)

{

BinaryTreeArray tree = new BinaryTreeArray(10);

tree.add(1);

tree.add(12);

tree.add(9);

tree.add(5);

tree.add(6);

System.out.println("Inorder traversal");

tree.inorder(0);

System.out.println("\nPreorder traversal");

tree.preorder(0);

System.out.println("\nPostorder traversal");

tree.postorder(0);

}

}
```

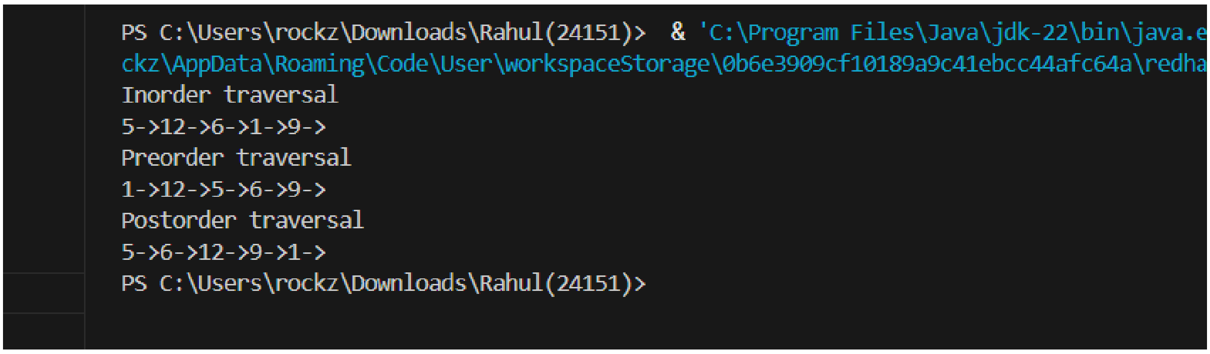


```
PS C:\Users\rockz\Downloads\Rahul(24151)>  & 'C:\Program F
ng\Code\User\workspaceStorage\0b6e3909cf10189a9c41ebcc44af
Inorder traversal
5->12->6->1->9->
Preorder traversal
1->12->5->6->9->
Postorder traversal
5->6->12->9->1->
PS C:\Users\rockz\Downloads\Rahul(24151)>
```

70. **binary tree using Linked Lits**

```
class Node
{
int item;
Node left;
Node right;
public Node(int key)
{
item = key;
left = null;
right = null;
}
}
class BinaryTree
{
Node root;
BinaryTree()
{
root = null;
}
void postorder(Node node)
{
if (node == null)
return;
postorder(node.left);
postorder(node.right);
System.out.print(node.item + "->");
}
```

```
void inorder(Node node)
{
if (node == null)
return;
inorder(node.left);
System.out.print(node.item + "->");
inorder(node.right);
}
void preorder(Node node)
{
if (node == null)
return;
System.out.print(node.item + "->");
preorder(node.left);
preorder(node.right);
}
public static void main(String[] args)
{
BinaryTree tree = new BinaryTree();
tree.root = new Node(1);
tree.root.left = new Node(12);
tree.root.right = new Node(9);
tree.root.left.left = new Node(5);
tree.root.left.right = new Node(6);
System.out.println("Inorder traversal");
tree.inorder(tree.root);
System.out.println("\nPreorder traversal ");
tree.preorder(tree.root);
System.out.println("\nPostorder traversal");

tree.postorder(tree.root);

}

}
```



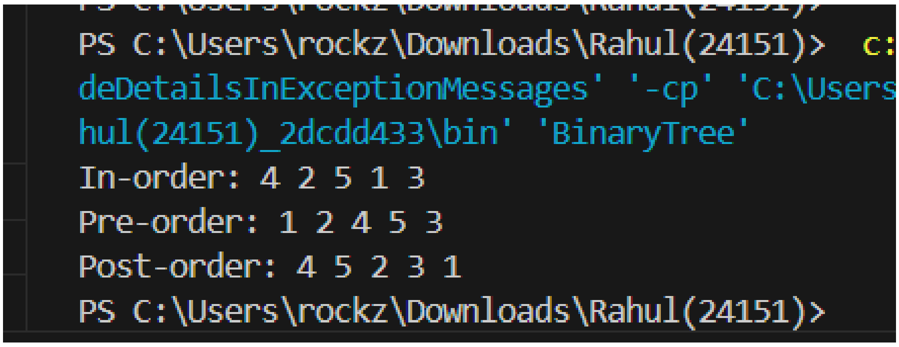
```
PS C:\Users\rockz\Downloads\Rahul(24151)>  & 'C:\Program Files\Java\jdk-22\bin\java.e
ckz\AppData\Roaming\Code\User\workspaceStorage\0b6e3909cf10189a9c41ebcc44afc64a\redha
Inorder traversal
5->12->6->1->9->
Preorder traversal
1->12->5->6->9->
Postorder traversal
5->6->12->9->1->
PS C:\Users\rockz\Downloads\Rahul(24151)>
```

71. Tree Traversals (Pre,inorder,postorder)

```
 // Node definition

class Node {

   int value;

   Node left, right;


   Node(int value) {

      this.value = value;

      left = right = null;

   }

}


// Binary tree with in-order, pre-order, post-order traversals
```

```
public class BinaryTree {
  Node root;

  // In-order: left → root → right
  void inOrder(Node node) {
    if (node == null) return;
    inOrder(node.left);
    System.out.print(node.value + " ");
    inOrder(node.right);
  }

  // Pre-order: root → left → right
  void preOrder(Node node) {
    if (node == null) return;
    System.out.print(node.value + " ");
    preOrder(node.left);
    preOrder(node.right);
  }

  // Post-order: left → right → root
  void postOrder(Node node) {
    if (node == null) return;
    postOrder(node.left);
    postOrder(node.right);
    System.out.print(node.value + " ");
  }

  public static void main(String[] args) {
    BinaryTree tree = new BinaryTree();
    // Manually build:
    tree.root = new Node(1);
    tree.root.left = new Node(2);
    tree.root.right = new Node(3);
    tree.root.left.left = new Node(4);
    tree.root.left.right = new Node(5);

    System.out.print("In-order: ");
    tree.inOrder(tree.root);
    System.out.println();

    System.out.print("Pre-order: ");
    tree.preOrder(tree.root);
    System.out.println();

    System.out.print("Post-order: ");
    tree.postOrder(tree.root);
```

```
    System.out.println();
  }
}
```



```
PS C:\Users\rockz\Downloads\Rahul(24151)>
PS C:\Users\rockz\Downloads\Rahul(24151)>  c:
deDetailsInExceptionMessages' '-cp' 'C:\Users
hul(24151)_2dcdd433\bin' 'BinaryTree'
In-order: 4 2 5 1 3
Pre-order: 1 2 4 5 3
Post-order: 4 5 2 3 1
PS C:\Users\rockz\Downloads\Rahul(24151)>
```

Lab_10 (11-04-25)

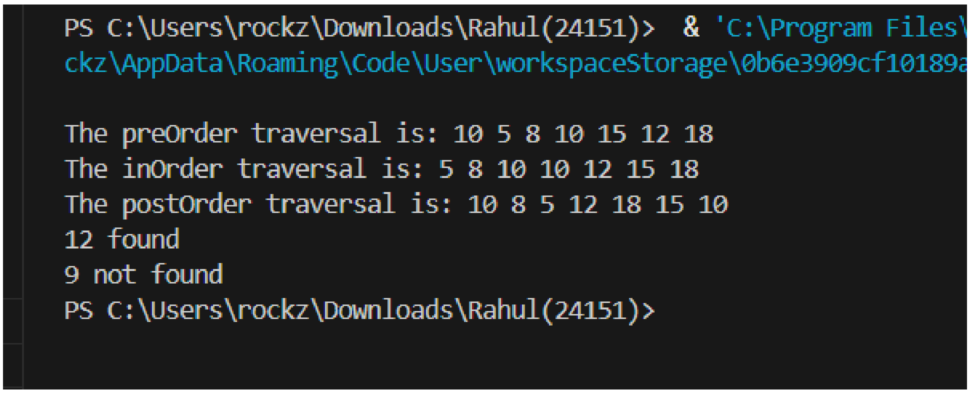
72. **Binary search Tree using array**

```
// BSTArray class to implement a binary search tree using an array
class BSTArray {
  Integer[] tree;    // Array to store the tree elements
```

```
int capacity;      // Maximum number of nodes the tree can hold

// Constructor to initialize the tree array with a specific size
public BSTArray(int size) {
    capacity = size;
    tree = new Integer[capacity]; // Initially, all values are null
}

// Public method to start insertion from root (index 0)
public void insert(int key) {
    insertAt(0, key); // Start recursive insertion at root
}

// Recursive helper to insert at a specific index
private void insertAt(int index, int key) {
    // If index goes out of bounds, show message
    if (index >= capacity) {
        System.out.println("Tree capacity exceeded");
        return;
    }

    // If position is empty, insert key here
    if (tree[index] == null) {
        tree[index] = key;
        return;
    }

    // If key is less than or equal, insert to left child
    if (key <= tree[index]) {
        insertAt(2 * index + 1, key); // Left child index = 2*i + 1
    } else {
        insertAt(2 * index + 2, key); // Right child index = 2*i + 2
    }
}

// Public method to search for a key in the tree
public boolean search(int key) {
    return searchAt(0, key); // Start from root
}

// Recursive helper to search starting from a given index
private boolean searchAt(int index, int key) {
    if (index >= capacity || tree[index] == null) {
        return false; // Reached beyond leaf or empty node
    }

    if (tree[index] == key) {
        return true; // Key found
    } else if (key < tree[index]) {
        return searchAt(2 * index + 1, key); // Search in left subtree
    } else {
        return searchAt(2 * index + 2, key); // Search in right subtree
    }
}

// Public method to perform inOrder traversal
```

```
public void inOrder() {
   System.out.print("The inOrder traversal is: ");
   inOrder(0); // Start from root
   System.out.println();
}

// Recursive inOrder: Left -> Root -> Right
private void inOrder(int index) {
   if (index >= capacity || tree[index] == null) return;
   inOrder(2 * index + 1);       // Visit left subtree
   System.out.print(tree[index] + " "); // Visit root
   inOrder(2 * index + 2);       // Visit right subtree
}

// Public method to perform preOrder traversal
public void preOrder() {
   System.out.print("The preOrder traversal is: ");
   preOrder(0);
   System.out.println();
}

// Recursive preOrder: Root -> Left -> Right
private void preOrder(int index) {
   if (index >= capacity || tree[index] == null) return;
   System.out.print(tree[index] + " "); // Visit root
   preOrder(2 * index + 1);          // Visit left subtree
   preOrder(2 * index + 2);          // Visit right subtree
}
```

```
    // Public method to perform postOrder traversal
    public void postOrder() {
        System.out.print("The postOrder traversal is: ");
        postOrder(0);
        System.out.println();
    }

    // Recursive postOrder: Left -> Right -> Root
    private void postOrder(int index) {
        if (index >= capacity || tree[index] == null) return;
        postOrder(2 * index + 1);    // Visit left subtree
        postOrder(2 * index + 2);    // Visit right subtree
        System.out.print(tree[index] + " "); // Visit root
    }
}
// Main class to test BSTArray
public class BinarySearchTreeArray {
    public static void main(String[] args) {
        BSTArray bst = new BSTArray(31); // Initialize array-based BST with 31 capacity

        // Insert elements
        bst.insert(10);
        bst.insert(15);
        bst.insert(5);
        bst.insert(8);
        bst.insert(18);
        bst.insert(12);
    bst.insert(10); // Duplicate (will be placed on left side again)

    // Display all traversals
    bst.preOrder();   // Root -> Left -> Right
    bst.inOrder();    // Left -> Root -> Right
    bst.postOrder();  // Left -> Right -> Root

    // Search for two elements
    search(bst, 12);  // Should be found
    search(bst, 9);   // Should not be found
  }

  // Helper method for searching and printing result
  private static void search(BSTArray bst, int key) {
    if (bst.search(key)) {
      System.out.println(key + " found");
    } else {
      System.out.println(key + " not found");
    }
  }
}
```



```
PS C:\Users\rockz\Downloads\Rahul(24151)>  & 'C:\Program Files\
ckz\AppData\Roaming\Code\User\workspaceStorage\0b6e3909cf10189a

The preOrder traversal is: 10 5 8 10 15 12 18
The inOrder traversal is: 5 8 10 10 12 15 18
The postOrder traversal is: 10 8 5 12 18 15 10
12 found
9 not found
PS C:\Users\rockz\Downloads\Rahul(24151)>
```

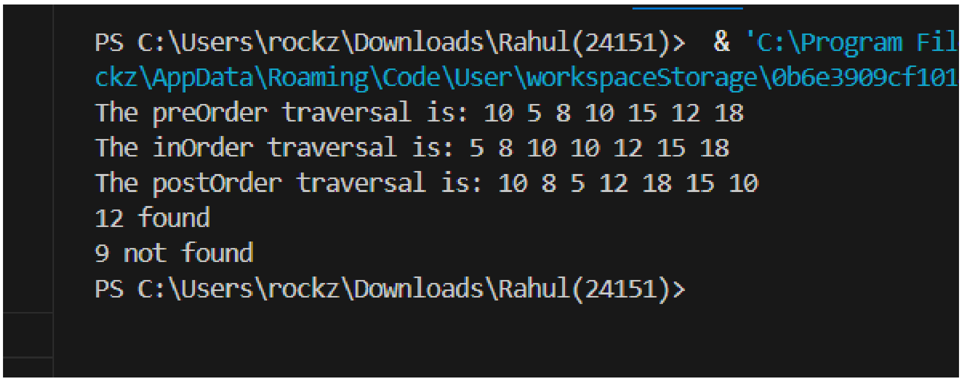
73. Binary Search tree using Linked Lists

```
class Node
{
int key;
Node left;
Node right;
public Node(int key)
{
this.key = key;
}
}
class BST
{
private Node root;
public void insert(int key)
{
root = insert(root, key);
}
private Node insert(Node node, int key)
{
if (node == null)
{
return new Node(key);
}
if (key <= node.key)
{
```

```
node.left = insert(node.left, key);
}
else
{
node.right = insert(node.right, key);
}
return node;
}
public Node search(int key)
{
return search(root, key);
}
private Node search(Node node, int key)
{
if (node == null || node.key == key)
{
return node;
}
if (key <= node.key)
{
return search(node.left, key);
}
return search(node.right, key);
}
public void inOrder()
{
System.out.print("The inOrder traversal is: ");
inOrder(root);
```

```
System.out.println();

}

private void inOrder(Node node)

{

if (node == null)

{

return;

}

inOrder(node.left);

System.out.print(node.key + " ");

inOrder(node.right);

}

public void preOrder()

{

System.out.print("The preOrder traversal is: ");

preOrder(root);

System.out.println();

}

private void preOrder(Node node)

{

if (node == null)

{

return;

}

System.out.print(node.key + " ");

preOrder(node.left);

preOrder(node.right);

}
```

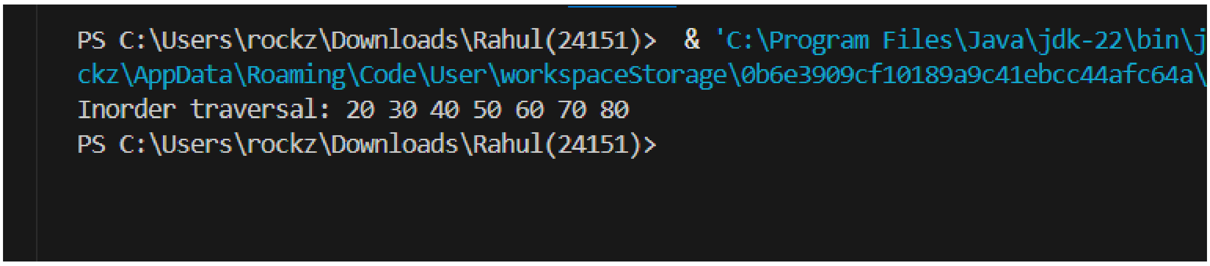
```
public void postOrder()
{
System.out.print("The postOrder traversal is: ");
postOrder(root);
System.out.println();
}
private void postOrder(Node node)
{
if (node == null)
{
return;
}
postOrder(node.left);
postOrder(node.right);
System.out.print(node.key + " ");
}
}
public class BinarySearchTree
{
public static void main(String[] args)
{
BST bst = new BST();
bst.insert(10);
bst.insert(15);
bst.insert(5);
bst.insert(8);
bst.insert(18);
bst.insert(12);
bst.insert(10);
bst.preOrder();
bst.inOrder();
bst.postOrder();
search(bst, 12);
search(bst, 9);
}
private static void search(BST bst, int key) {
if (bst.search(key) != null) {
System.out.println(key + " found");
}
else
{
System.out.println(key + " not found");
}
}
}
```



```
PS C:\Users\rockz\Downloads\Rahul(24151)>  & 'C:\Program Fil
ckz\AppData\Roaming\Code\User\workspaceStorage\0b6e3909cf101
The preOrder traversal is: 10 5 8 10 15 12 18
The inOrder traversal is: 5 8 10 10 12 15 18
The postOrder traversal is: 10 8 5 12 18 15 10
12 found
9 not found
PS C:\Users\rockz\Downloads\Rahul(24151)>
```

74. Implement a program to insert elements into a binary search tree.

```
// Import necessary classes
public class BSTInsertion {

  // Node class to represent each node in the BST
  static class Node {
    int data;      // Value of the node
    Node left;     // Reference to the left child
    Node right;    // Reference to the right child

    // Constructor to create a new node
    Node(int data) {
      this.data = data;
      this.left = null;
      this.right = null;
    }
  }

  // Method to insert a new node into the BST
  public static Node insert(Node root, int data) {
    // If tree is empty, create a new node and return it
    if (root == null) {
      return new Node(data);
    }

    // If data is less than root's data, insert in the left subtree
    if (data < root.data) {
        root.left = insert(root.left, data);
    }
    // If data is greater than root's data, insert in the right subtree
    else if (data > root.data) {
        root.right = insert(root.right, data);
    }

    // Return the unchanged root node
    return root;
}

// Method for inorder traversal of the BST
public static void inorderTraversal(Node root) {
    if (root == null) {
        return; // Base case: if node is null, return
    }

    inorderTraversal(root.left);     // Visit left subtree
    System.out.print(root.data + " "); // Print current node's data
    inorderTraversal(root.right);    // Visit right subtree
}

// Main method to execute the program
public static void main(String[] args) {
    Node root = null; // Initially the BST is empty

    // Insert elements into the BST
    root = insert(root, 50);
    insert(root, 30);

    insert(root, 20);

    insert(root, 40);

    insert(root, 70);

    insert(root, 60);

    insert(root, 80);


    // Display inorder traversal (sorted order)

    System.out.print("Inorder traversal: ");

    inorderTraversal(root);

    System.out.println();

  }

}
```



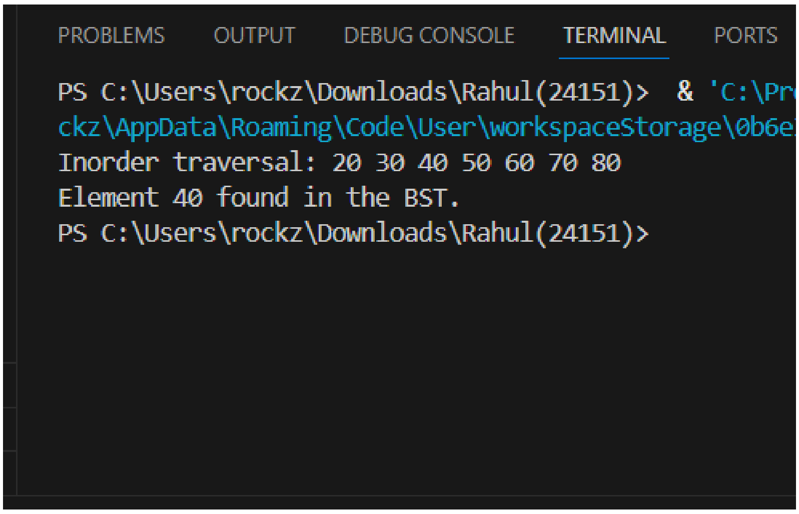
```
PS C:\Users\rockz\Downloads\Rahul(24151)>  & 'C:\Program Files\Java\jdk-22\bin\j
ckz\AppData\Roaming\Code\User\workspaceStorage\0b6e3909cf10189a9c41ebcc44afc64a\
Inorder traversal: 20 30 40 50 60 70 80
PS C:\Users\rockz\Downloads\Rahul(24151)>
```

75.) to implement a program to search for an element in a binary search tree

```
// Main class

public class BSTSearch {


  // Node class definition to represent each node of the BST

  static class Node {

    int data;      // The data value stored in the node

    Node left;     // Pointer to the left child
    Node right;    // Pointer to the right child

    // Constructor to initialize a new node with data
    Node(int data) {
        this.data = data;
        this.left = null;
        this.right = null;
    }
}

// Method to insert a new element into the BST
public static Node insertNode(Node root, int data) {
    // If the current position is null, we place the new node here
    if (root == null) {
        return new Node(data); // Create and return a new node
    }

    // If the new data is smaller, insert in the left subtree
    if (data < root.data) {
        root.left = insertNode(root.left, data);
    }
    // If the new data is larger, insert in the right subtree
    else if (data > root.data) {
        root.right = insertNode(root.right, data);
    }

    // Return the current root node after insertion
    return root;
```

```
}

// Method to search for a key in the BST
public static Node searchNode(Node root, int key) {
    // Base condition: if root is null or key matches the current node's data
    if (root == null || root.data == key) {
        return root; // Key found or not present in the tree
    }

    // If key is smaller than current node's data, search in the left subtree
    if (key < root.data) {
        return searchNode(root.left, key);
    }

    // If key is greater than current node's data, search in the right subtree
    return searchNode(root.right, key);
}

// Method for inorder traversal (Left -> Root -> Right)
public static void inorderTraversal(Node root) {
    if (root == null) return;

    inorderTraversal(root.left);         // Visit left subtree
    System.out.print(root.data + " ");    // Print current node
    inorderTraversal(root.right);        // Visit right subtree
}

// Main method: Entry point of the program
```

```
public static void main(String[] args) {
  Node root = null; // Initialize the BST as empty

  // Insert elements into the BST
  root = insertNode(root, 50);
  insertNode(root, 30);
  insertNode(root, 20);
  insertNode(root, 40);
  insertNode(root, 70);
  insertNode(root, 60);
  insertNode(root, 80);

  // Print the BST using inorder traversal (should be sorted)
  System.out.print("Inorder traversal: ");
  inorderTraversal(root);
  System.out.println();

  // Define the key to be searched
  int key = 40;

  // Perform search operation in the BST
  Node result = searchNode(root, key);

  // Check if the element is found or not
  if (result != null) {
    System.out.println("Element " + key + " found in the BST.");
  } else {
    System.out.println("Element " + key + " not found in the BST.");
    }
  }
}
```

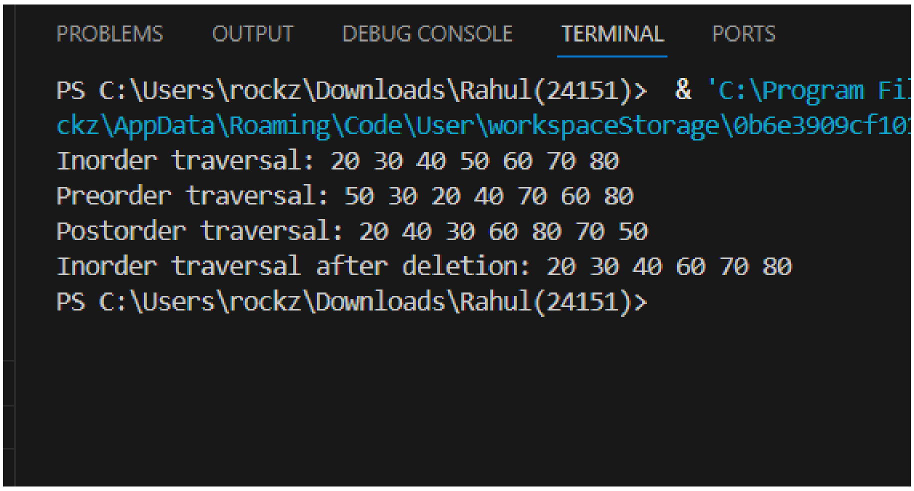


```
PS C:\Users\rockz\Downloads\Rahul(24151)>  & 'C:\Pr
ckz\AppData\Roaming\Code\User\workspaceStorage\0b6e
Inorder traversal: 20 30 40 50 60 70 80
Element 40 found in the BST.
PS C:\Users\rockz\Downloads\Rahul(24151)>
```

76. **Implement a program to delete a node from a binary search tree.**

```
// Define the main class
public class BSTDeletion {

  // Define the structure of a BST node
  static class Node {
    int data;      // Data value of the node
    Node left;     // Pointer to left child
    Node right;    // Pointer to right child
    // Constructor to initialize a node
    Node(int data) {
        this.data = data;
        this.left = null;
        this.right = null;
    }
}

// Function to perform inorder traversal (Left → Root → Right)
public static void inorderTraversal(Node root) {
    if (root == null) return;           // Base case: empty node
    inorderTraversal(root.left);        // Visit left subtree
    System.out.print(root.data + " ");  // Visit root
    inorderTraversal(root.right);       // Visit right subtree
}

// Function to perform preorder traversal (Root → Left → Right)
public static void preorderTraversal(Node root) {
    if (root == null) return;
    System.out.print(root.data + " ");  // Visit root
    preorderTraversal(root.left);       // Visit left
    preorderTraversal(root.right);      // Visit right
}

// Function to perform postorder traversal (Left → Right → Root)
public static void postorderTraversal(Node root) {
    if (root == null) return;
    postorderTraversal(root.left);      // Visit left
    postorderTraversal(root.right);     // Visit right
    System.out.print(root.data + " ");   // Visit root
}

// Utility function to find the minimum value node in the right subtree
public static Node findMin(Node root) {
    while (root.left != null) {
        root = root.left;   // Go as left as possible
    }
    return root;
}

// Function to delete a node from the BST
public static Node deleteNode(Node root, int key) {
    if (root == null) return null;   // Base case: key not found

    if (key < root.data) {
        // If key is smaller than root, go left
        root.left = deleteNode(root.left, key);
    } else if (key > root.data) {
        // If key is larger than root, go right
        root.right = deleteNode(root.right, key);
    } else {
        // Node to delete found
        // Case 1: Node with only right child or no child
        if (root.left == null) {
            return root.right; // Replace with right subtree
        }
        // Case 2: Node with only left child
        else if (root.right == null) {
            return root.left;  // Replace with left subtree
        }

        // Case 3: Node with two children
        // Find inorder successor (smallest in the right subtree)
        Node temp = findMin(root.right);

        // Copy the successor's value to the root
        root.data = temp.data;

        // Delete the inorder successor recursively
        root.right = deleteNode(root.right, temp.data);
    }

    // Return the updated root reference
    return root;
}

// Main method
public static void main(String[] args) {
    // Manually constructing the BST as per the original C code
    Node root = new Node(50);
    root.left = new Node(30);
    root.right = new Node(70);
    root.left.left = new Node(20);
```

```
        root.left.right = new Node(40);
        root.right.left = new Node(60);
        root.right.right = new Node(80);

        // Print initial traversals
        System.out.print("Inorder traversal: ");
        inorderTraversal(root);
        System.out.println();

        System.out.print("Preorder traversal: ");
        preorderTraversal(root);
        System.out.println();

        System.out.print("Postorder traversal: ");
        postorderTraversal(root);
        System.out.println();

        // Delete node with value 50 (root)
        root = deleteNode(root, 50);

        // Print inorder after deletion
        System.out.print("Inorder traversal after deletion: ");
        inorderTraversal(root);
        System.out.println();
    }
}
```



```
PS C:\Users\rockz\Downloads\Rahul(24151)>  & 'C:\Program Fi
ckz\AppData\Roaming\Code\User\workspaceStorage\0b6e3909cf10
Inorder traversal: 20 30 40 50 60 70 80
Preorder traversal: 50 30 20 40 70 60 80
Postorder traversal: 20 40 30 60 80 70 50
Inorder traversal after deletion: 20 30 40 60 70 80
PS C:\Users\rockz\Downloads\Rahul(24151)>
```

LAB_11 (25-4-25)

77. AVL insertion

```
// Class representing a node in the AVL Tree
class Node {
    int key;         // Value of the node
    Node left, right; // References to left and right child nodes
    int height;      // Height of the node in the tree

    Node(int key) {
        this.key = key;
        this.height = 1; // New node starts with height 1 (leaf node)
    }
}

public class AVLTree {

    // Function to get the height of a node
    int getHeight(Node node) {
        if (node == null) return 0;  // Null node has height 0
        return node.height;
    }

    // Function to get the balance factor of a node
    int getBalanceFactor(Node node) {
        if (node == null) return 0;
        return getHeight(node.left) - getHeight(node.right);
    // Balance Factor = height of left subtree - height of right
subtree
  }
```

- // Utility function to get the maximum of two integers(used in height calculation).(which side is greater left sub tree or right sub tree)

```
  int max(int a, int b) {
```

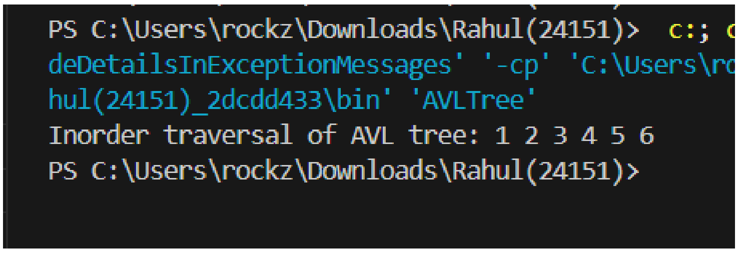
- return (a > b) ? a : b;   }

```
  // Right rotation (used for LL and LR imbalance)
  Node rightRotate(Node y) {
    Node x = y.left;      // x is left child of y
    Node T2 = x.right;    // T2 is the right child of x (may be null)

    // Perform rotation
    x.right = y;          // Make y the right child of x
    y.left = T2;          // T2 becomes the left child of y

    // Update heights
    y.height = max(getHeight(y.left), getHeight(y.right)) + 1;
    x.height = max(getHeight(x.left), getHeight(x.right)) + 1;
    // Return new root
    return x;
}

// Left rotation (used for RR and RL imbalance)
Node leftRotate(Node x) {
    Node y = x.right;     // y is right child of x
    Node T2 = y.left;     // T2 is the left child of y

    // Perform rotation
    y.left = x;           // Make x the left child of y
    x.right = T2;         // T2 becomes the right child of x

    // Update heights
    x.height = max(getHeight(x.left), getHeight(x.right)) + 1;
    y.height = max(getHeight(y.left), getHeight(y.right)) + 1;

    // Return new root
    return y;
}

// Function to insert a key and return new root of AVL tree
```

```
    Node insert(Node node, int key) {
        // 1. Standard BST Insertion
        if (node == null)
            return new Node(key); // If node is null, insert here

        if (key < node.key)
            node.left = insert(node.left, key);    // Insert into left subtree
        else if (key > node.key)
            node.right = insert(node.right, key);  // Insert into right subtree
        else
            return node; // Duplicates not allowed in BST

        // 2. Update height of the ancestor node
        node.height = 1 + max(getHeight(node.left), getHeight(node.right));

        // 3. Get the balance factor to check for imbalance
        int balance = getBalanceFactor(node);

        // 4. Balance the tree with 4 possible cases

        // Case 1: Left Left (LL)
    if (balance > 1 && key < node.left.key)
      return rightRotate(node);

    // Case 2: Right Right (RR)
    if (balance < -1 && key > node.right.key)
      return leftRotate(node);

    // Case 3: Left Right (LR)
    if (balance > 1 && key > node.left.key) {
      node.left = leftRotate(node.left);  // First left rotate child
      return rightRotate(node);        // Then right rotate current
node
    }

    // Case 4: Right Left (RL)
    if (balance < -1 && key < node.right.key) {
      node.right = rightRotate(node.right); // First right rotate child
      return leftRotate(node);          // Then left rotate current
node
    }

    return node; // Return unchanged node pointer
  }
```

```
// Function to print inorder traversal of AVL tree
void inOrder(Node root) {
    if (root != null) {
        inOrder(root.left);         // Left subtree
        System.out.print(root.key + " "); // Current node
        inOrder(root.right);        // Right subtree
    }
}

// Main method
public static void main(String[] args) {
    AVLTree tree = new AVLTree();
    Node root = null;

    // Insert nodes into AVL Tree
    root = tree.insert(root, 1);
    root = tree.insert(root, 2);
    root = tree.insert(root, 4);
    root = tree.insert(root, 5);
    root = tree.insert(root, 6); // RR Rotation happens here
    root = tree.insert(root, 3); // RL Rotation happens here
```

```
        // Inorder Traversal of AVL Tree
        System.out.print("Inorder traversal of AVL tree: ");
        tree.inOrder(root);  // Output will be sorted: 1 2 3 4 5 6
    }
}
```



```
PS C:\Users\rockz\Downloads\Rahul(24151)>  c:; c
deDetailsInExceptionMessages' '-cp' 'C:\Users\ro
hul(24151)_2dcdd433\bin' 'AVLTree'
Inorder traversal of AVL tree: 1 2 3 4 5 6
PS C:\Users\rockz\Downloads\Rahul(24151)>
```

78. AVL DELETE

```
// Node class to represent each node in the AVL tree
class Node {
    int key;        // The value stored in the node
    Node left, right; // References to left and right child nodes
    int height;      // Height of this node in the AVL tree
```

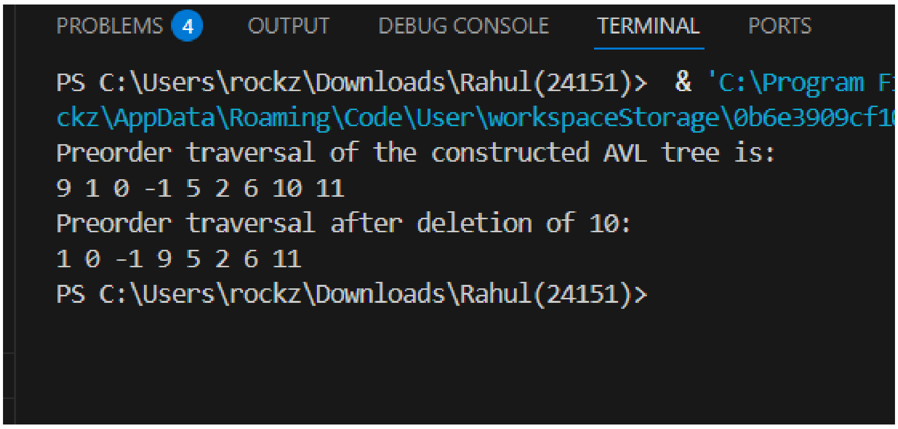
```
  // Constructor to create a new node with a given key
  Node(int k) {
    key = k;        // Initialize the key with given value
    left = right = null; // Initially, no children
    height = 1;      // Height of a new node is 1 (leaf node)
  }
}

// Main class containing AVL tree methods
public class Main {

  // Utility method to get height of a node (returns 0 if node is null)
  static int height(Node N) {
    if (N == null)      // If node is null
      return 0;       // Height is 0
    return N.height;     // Otherwise return node's height
  }

  // Right rotate subtree rooted with y
  static Node rightRotate(Node y) {
    Node x = y.left;     // x is left child of y (new root after rotation)
    Node T2 = x.right;    // Temporarily store x's right subtree

    // Perform rotation
    x.right = y;        // Make y the right child of x
    y.left = T2;        // Attach T2 as left child of y

    // Update heights of rotated nodes
    y.height = Math.max(height(y.left), height(y.right)) + 1; // y height updated first
    x.height = Math.max(height(x.left), height(x.right)) + 1; // then x height updated

    return x;          // Return new root node after rotation
  }

  // Left rotate subtree rooted with x
  static Node leftRotate(Node x) {
    Node y = x.right;    // y is right child of x (new root after rotation)
    Node T2 = y.left;    // Temporarily store y's left subtree

    // Perform rotation
    y.left = x;         // Make x the left child of y
    x.right = T2;       // Attach T2 as right child of x

    // Update heights of rotated nodes
    x.height = Math.max(height(x.left), height(x.right)) + 1; // update x height
    y.height = Math.max(height(y.left), height(y.right)) + 1; // update y height

    return y;          // Return new root node after rotation
  }

  // Get balance factor of node N (height of left subtree - right subtree)
  static int getBalance(Node N) {
    if (N == null)      // If node is null
      return 0;       // balance is 0
    return height(N.left) - height(N.right); // difference of heights
  }
```

```
// Recursive method to insert a key into the subtree rooted with node and
// return the new root of the subtree after balancing
static Node insert(Node node, int key) {
  // 1. Normal BST insertion
  if (node == null)          // If current node is null
    return new Node(key);    // Create a new node with key

  // If key is less than node's key, insert in left subtree
  if (key < node.key)
    node.left = insert(node.left, key);
  // If key is greater than node's key, insert in right subtree
  else if (key > node.key)
    node.right = insert(node.right, key);
  else                 // Duplicate keys not allowed
    return node;

  // 2. Update height of this ancestor node
  node.height = Math.max(height(node.left), height(node.right)) + 1;

  // 3. Get the balance factor of this node to check if unbalanced
  int balance = getBalance(node);

  // 4. If unbalanced, then check 4 cases

  // Left Left Case: imbalance caused by inserting in left subtree of left child
  if (balance > 1 && key < node.left.key)
    return rightRotate(node);  // Perform right rotation
  // Right Right Case: imbalance caused by inserting in right subtree of right child
  if (balance < -1 && key > node.right.key)
    return leftRotate(node);   // Perform left rotation

  // Left Right Case: imbalance caused by inserting in right subtree of left child
  if (balance > 1 && key > node.left.key) {
    node.left = leftRotate(node.left);  // First left rotate left child
    return rightRotate(node);           // Then right rotate node
  }

  // Right Left Case: imbalance caused by inserting in left subtree of right child
  if (balance < -1 && key < node.right.key) {
    node.right = rightRotate(node.right); // First right rotate right child
    return leftRotate(node);              // Then left rotate node
  }

  // Return the unchanged node pointer
  return node;
}

// Utility function to find node with minimum key value in subtree rooted with node
static Node minValueNode(Node node) {
  Node current = node;

  // Loop to find the leftmost leaf
  while (current.left != null)
    current = current.left;
```

```
  return current;  // Return node with minimum key
}

// Recursive method to delete a node with given key from subtree with given root
// Returns new root of the subtree after deletion and balancing
static Node deleteNode(Node root, int key) {
  // STEP 1: Perform standard BST delete

  if (root == null)   // If tree is empty
    return root;    // Return null

  // If key to be deleted is smaller than root's key, go to left subtree
  if (key < root.key)
    root.left = deleteNode(root.left, key);

  // If key to be deleted is greater than root's key, go to right subtree
  else if (key > root.key)
    root.right = deleteNode(root.right, key);

  else {  // Found node to be deleted

    // Node with only one child or no child
    if ((root.left == null) || (root.right == null)) {
      Node temp = null;

      // Assign temp to non-null child if any
      if (root.left != null)
        temp = root.left;
      else
        temp = root.right;

      // No child case
      if (temp == null) {
        temp = root;   // Temporarily store root node
        root = null;   // Delete root (make it null)
      } else // One child case
        root = temp;   // Copy child to root
    } else {
      // Node with two children:
      // Get inorder successor (smallest in right subtree)
      Node temp = minValueNode(root.right);

      // Copy inorder successor's key to root
      root.key = temp.key;

      // Delete inorder successor recursively
      root.right = deleteNode(root.right, temp.key);
    }
  }

  // If tree had only one node and now root is null, return
  if (root == null)
    return root;

  // STEP 2: Update height of current node
```

```
root.height = Math.max(height(root.left), height(root.right)) + 1;

// STEP 3: Get balance factor of current node
int balance = getBalance(root);

// STEP 4: If node unbalanced, then balance it with rotations

// Left Left Case
if (balance > 1 && getBalance(root.left) >= 0)
  return rightRotate(root);

// Left Right Case
if (balance > 1 && getBalance(root.left) < 0) {
  root.left = leftRotate(root.left);
  return rightRotate(root);
}

// Right Right Case
if (balance < -1 && getBalance(root.right) <= 0)
  return leftRotate(root);

// Right Left Case
if (balance < -1 && getBalance(root.right) > 0) {
  root.right = rightRotate(root.right);
  return leftRotate(root);
}

// Return the balanced node pointer
```

```
    return root;
}

// Utility function for preorder traversal of the tree
static void preOrder(Node root) {
    if (root != null) {
        System.out.print(root.key + " "); // Print root key
        preOrder(root.left);             // Traverse left subtree
        preOrder(root.right);            // Traverse right subtree
    }
}

// Main method to test the AVL tree implementation
public static void main(String[] args) {
    Node root = null;  // Start with empty tree

    // Insert nodes into AVL tree
    root = insert(root, 9);
    root = insert(root, 5);
    root = insert(root, 10);
    root = insert(root, 0);
    root = insert(root, 6);
    root = insert(root, 11);
    root = insert(root, -1);
    root = insert(root, 1);
    root = insert(root, 2);

    // Print preorder traversal of the constructed AVL tree
    System.out.println("Preorder traversal of the constructed AVL tree is:");
    preOrder(root);

    // Delete node with key 10
    root = deleteNode(root, 10);

    // Print preorder traversal after deletion
    System.out.println("\nPreorder traversal after deletion of 10:");
    preOrder(root);
  }
}
```



```
PS C:\Users\rockz\Downloads\Rahul(24151)>  & 'C:\Program F
ckz\AppData\Roaming\Code\User\workspaceStorage\0b6e3909cf1
Preorder traversal of the constructed AVL tree is:
9 1 0 -1 5 2 6 10 11
Preorder traversal after deletion of 10:
1 0 -1 9 5 2 6 11
PS C:\Users\rockz\Downloads\Rahul(24151)>
```

79. AVL using Arrays

```
public class AVLArray {
  int MAX = 100;        // max nodes
  int[] keys = new int[MAX];    // keys of nodes
  int[] heights = new int[MAX]; // heights of nodes
  int[] left = new int[MAX];    // left child indices
  int[] right = new int[MAX];   // right child indices
  boolean[] used = new boolean[MAX]; // to check used slots
```

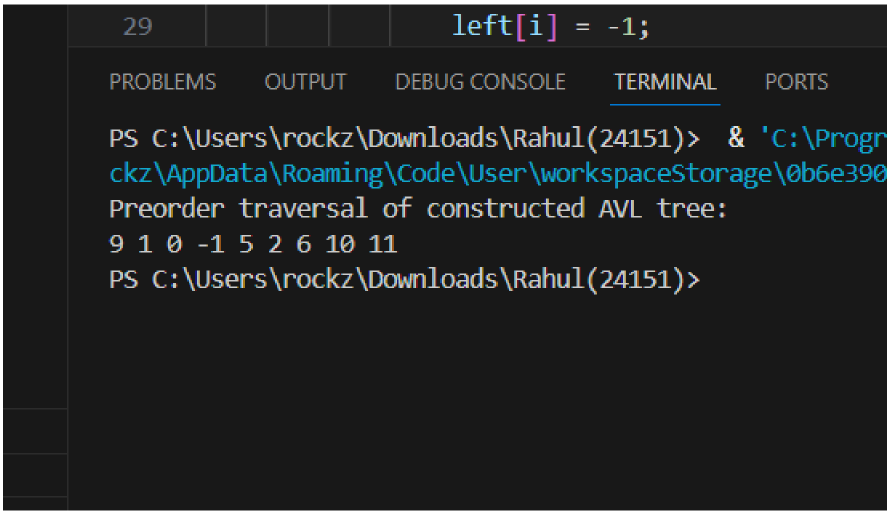
```
int root = -1;        // root index, -1 means empty tree

// Constructor initializes arrays
public AVLArray() {
  for (int i = 0; i < MAX; i++) {
    left[i] = -1;   // no left child initially
    right[i] = -1;  // no right child initially
    heights[i] = 0; // height zero for unused nodes
    used[i] = false;
  }
}

// Allocate new node index with given key
int newNode(int key) {
  for (int i = 0; i < MAX; i++) {
    if (!used[i]) {
      used[i] = true;
      keys[i] = key;
      heights[i] = 1;   // new node height = 1
      left[i] = -1;
      right[i] = -1;
      return i;
    }
  }
  throw new RuntimeException("Out of space!");
}
```

```
// Get height of node at index i

int height(int i) {

   if (i == -1) return 0;

   return heights[i];

}


// Update height of node i

void updateHeight(int i) {

   heights[i] = Math.max(height(left[i]), height(right[i])) + 1;

}


// Get balance factor of node i

int getBalance(int i) {

   if (i == -1) return 0;

   return height(left[i]) - height(right[i]);

}


// Right rotate subtree rooted at y

int rightRotate(int y) {

   int x = left[y];

   int T2 = right[x];


   // Perform rotation

   right[x] = y;

   left[y] = T2;


   // Update heights

   updateHeight(y);
```

```
    updateHeight(x);

    // Return new root
    return x;
}

// Left rotate subtree rooted at x
int leftRotate(int x) {
    int y = right[x];
    int T2 = left[y];

    // Perform rotation
    left[y] = x;
    right[x] = T2;

    // Update heights
    updateHeight(x);
    updateHeight(y);

    // Return new root
    return y;
}

// Insert key into subtree rooted at nodeIndex, returns new root index of subtree
int insert(int nodeIndex, int key) {
    if (nodeIndex == -1) {
        return newNode(key);
    }
```

```
if (key < keys[nodeIndex]) {
   left[nodeIndex] = insert(left[nodeIndex], key);
} else if (key > keys[nodeIndex]) {
   right[nodeIndex] = insert(right[nodeIndex], key);
} else {
   // Duplicate keys not allowed
   return nodeIndex;
}

// Update height of this ancestor node
updateHeight(nodeIndex);

// Get balance factor
int balance = getBalance(nodeIndex);

// If node is unbalanced, fix it with rotations

// Left Left Case
if (balance > 1 && key < keys[left[nodeIndex]])
   return rightRotate(nodeIndex);

// Right Right Case
if (balance < -1 && key > keys[right[nodeIndex]])
   return leftRotate(nodeIndex);

// Left Right Case
if (balance > 1 && key > keys[left[nodeIndex]]) {
```

```
            left[nodeIndex] = leftRotate(left[nodeIndex]);
            return rightRotate(nodeIndex);
        }

        // Right Left Case
        if (balance < -1 && key < keys[right[nodeIndex]]) {
            right[nodeIndex] = rightRotate(right[nodeIndex]);
            return leftRotate(nodeIndex);
        }

        return nodeIndex;
    }

    // Preorder traversal of tree starting at index i
    void preOrder(int i) {
        if (i != -1) {
            System.out.print(keys[i] + " ");
            preOrder(left[i]);
            preOrder(right[i]);
        }
    }

    public static void main(String[] args) {
        AVLArray tree = new AVLArray();

        // Insert keys
        tree.root = tree.insert(tree.root, 9);
        tree.root = tree.insert(tree.root, 5);
        tree.root = tree.insert(tree.root, 10);

        tree.root = tree.insert(tree.root, 0);

        tree.root = tree.insert(tree.root, 6);

        tree.root = tree.insert(tree.root, 11);

        tree.root = tree.insert(tree.root, -1);

        tree.root = tree.insert(tree.root, 1);

        tree.root = tree.insert(tree.root, 2);


        System.out.println("Preorder traversal of constructed AVL tree:");

        tree.preOrder(tree.root);

    }

}
```



```
                left[i] = -1;
```

```
PS C:\Users\rockz\Downloads\Rahul(24151)>  & 'C:\Progr
ckz\AppData\Roaming\Code\User\workspaceStorage\0b6e390
Preorder traversal of constructed AVL tree:
9 1 0 -1 5 2 6 10 11
PS C:\Users\rockz\Downloads\Rahul(24151)>
```