practical 1

Aim: To implement searching techniques using JAVA

1. Linear search

2. Binary Search

3. Recursive binary search

Objectives:

1. To know what searching is and understand algorithm for Linear search and Binary search
2. To understand the basic principles of recursive definitions and functions and be able to write simple recursive function

Theory:

Searching: It is process of checking and finding an element from list of elements.

1. Linear search
2. Binary search

Pseudocode for Linear search:

Algorithm linear (a, n, key)

// key is data to be searched in array a of size length

Pre: Unsorted list of length n.

Post: If found, return position of key in array a. If key not present in list, return negative value

1. for i = 0 to (n - 1) do

if (key == a[i])

return i

2. return -1

Pseudocode for Binary search:

Algorithm binary_search (a, n, key)

// key - data to be searched in array a of size n

Pre: Sorted list of length n.

Post: If present, return position of key in array a; Else return -1

1. low =0
2. high = n-1

3. while (low <= high)

1. mid = (low + high)/2

2. if (key == a[mid])

return mid

3. if (key < a[mid])

high = mid -1

4 else

low = mid + 1

4. return -1

Pseudocode for Recursive binary search:

BinarySearch(a, key, low, high)

1. if (low > high)

return -1 // not found

2. mid = (low + high) / 2

3. if (key < a[mid])

return BinarySearch (a, key, low, mid-1)

4. else if (key > a[mid])

return BinarySearch (a, key, mid+1, high)

5. else

return mid // found

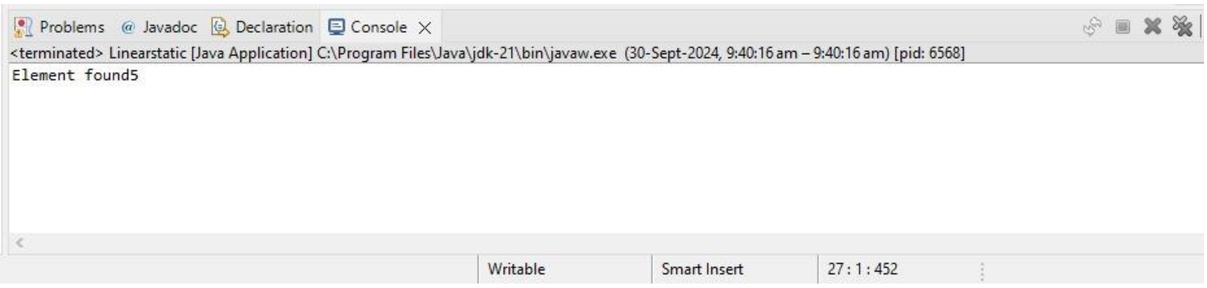
Program:

JAVA implementation for Linear search:

```
package LinearSearch;
import java.util.Scanner;
public class Linearstatic {
    public static void main(String[] args) {
        Scanner sc = new Scanner(System.in);
        int i,c=0,key,f=0;
```

```
		int [] a = {10,20,30,40,50};
		key = 50;
		for(i=0;i<a.length;i++)
		{
			if(a[i]==key)
			{
				f=1;
				break;
			}
			c++;
		}
		if(f==1)
			System.out.println("Element found"+(c+1));
		else
			System.out.println("Element not found");
	}
}
```

Output:

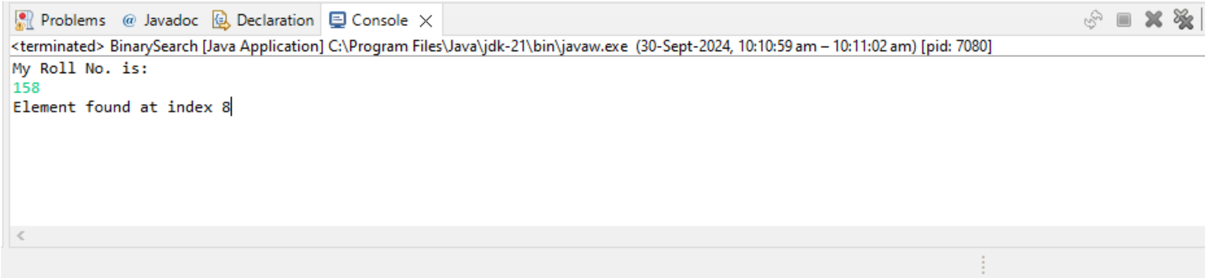


JAVA implementation for Binary search:

```
package BinarySearch;
import java.util.Scanner;
public class BinarySearch {
 int binarySearch(int array[], int element, int low, int high) {
   while (low <= high) {
     int mid = low + (high - low) / 2;
```

```
    if (array[mid] == element)
      return mid;
    if (element > array[mid])
      low = mid + 1;
    else
      high = mid - 1;
  }
  return -1;
 }
 public static void main(String args[]) {
  BinarySearch obj = new BinarySearch();
  int[] array = { 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160};
  int n = array.length;
  Scanner input = new Scanner(System.in);
  System.out.println("My Roll No. is:");
  int element = input.nextInt();
  input.close();
  int result = obj.binarySearch(array, element, 0, n - 1);
  if (result == -1)
    System.out.println("Not found");
  else
    System.out.println("Element found at index " + result);
 }
}
```

Output:



JAVA implementation for Recursive Binary search:

```
 package BinaryRecursiveSearch;

import java.util.Arrays;

import java.util.Scanner;

public class RecursiveSearch {

            int rec_bin_search(int my_arr[], int left, int right, int x) {

     if (right >= left) {

        int mid = left + (right - left) / 2;

        if (my_arr[mid] == x)

           return mid;

        if (my_arr[mid] > x)

           return rec_bin_search(my_arr, left, mid - 1, x);

        return rec_bin_search(my_arr, mid + 1, right, x);

     }

     return -1;

  }

  public static void main(String args[]) {

     Scanner scanner = new Scanner(System.in);


     System.out.print("Enter the number of elements in the array: ");

     int n = scanner.nextInt();

     int[] my_arr = new int[n];

     System.out.println("Enter the elements of the array:");

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

        my_arr[i] = scanner.nextInt();
```

```
        }
        System.out.print("Enter the element to search for: ");
        int x = scanner.nextInt();
        // Sort the array before binary search
        Arrays.sort(my_arr);
        RecursiveSearch my_object = new RecursiveSearch();
        int len = my_arr.length;
        int result = my_object.rec_bin_search(my_arr, 0, len - 1, x);

        if (result == -1)
            System.out.println("The element is not present in the array");
        else
            System.out.println("The element has been found at index " + result + " (in the sorted array)");
        System.out.println("Sorted array: " + Arrays.toString(my_arr));
        scanner.close();
    }
}
```

<u>Output:</u>

```
Problems  Javadoc  Declaration  Console
<terminated> RecursiveSearch [Java Application] C:\Program Files\Java\jdk-21\bin\javaw.exe (07-Oct-2024, 9:25:19 am – 9:25:42 am) [pid: 13128]
Enter the number of elements in the array: 6
Enter the elements of the array:
5
6
7
8
9
4
Enter the element to search for: 8
The element has been found at index 4 (in the sorted array)
Sorted array: [4, 5, 6, 7, 8, 9]
```

<u>Conclusion</u>:

Linear search is used for an unsorted small list of elements. It has a time complexity of **O(n)**,

Binary Search is used to search through large sorted arrays. It has a time complexity of **O(log n)**

Practical 2

Aim: To implement sorting techniques

1. Bubble Sort
2. Insertion Sort
3. Selection Sort
4. Shell Sort
5. Quick Sort
6. Merge Sort

Objectives:

1. To learn and understand the concept of sorting using different sorting techniques.

Theory:

Pseudo code for Bubble Sort:

Algorithm bubble (a, n)

Pre: Unsorted array a of length n.

Post: Sorted array in ascending order of length n

for i = 1 to (n – 1) do // n-1 passes

for j = 1 to (n- *i*) do

if (a[j] > a[j+1])

1. temp=a[j] //swapping of numbers
2. a[j]=a[j+1]
3. a[j+1]=temp

-

Pseudo code for Optimized Bubble Sort:

Algorithm bubble (a, n)

Pre: Unsorted array a of length n.

Post: Sorted array in ascending order of length n

1. for i = 1 to (n – 1) do // n-1 passes

1. *test = 0*

2. for j = 1 to (n– *i*) do

1. if (a[j] > a[j+1])

1. temp=a[j]

2. a[j]=a[j+1]

3. a[j+1]=temp

4. test = 1 // exchange happened

3. *if (test = 0)* //no exchange - list is now sorted

1. return

Pseudo code for Insertion Sort:

Algorithm insertion (a, n)

Pre: Unsorted list a of length n.

Post: Sorted list a in ascending order of length n

1. for i = 1 to (n -1) do // n-1 passes

1. temp = a[i] //value to be inserted

2. ptr = i – 1 //pointer to move downward

3. while (temp < a[ptr] and ptr >= 0)

1. a[ptr + 1] = a[ptr]

2. ptr = ptr - 1

4. a[ptr +1] = temp

-

Pseudo code for Selection Sort:

Algorithm selection (a, n)

Pre: Unsorted array a of length n.

Post: Sorted list in ascending order of length n

1. for i = 0 to (n -2) do // n-1 passes

1. min_index=i

2. for j = (i+1) to (n -1) do

1. if (a[min_index] > a[j])

1. min_index = j

3. if (min_index != i) //place smallest element at i^{th} place

1. temp= a[i]

2. a[i]=a[min_index

3. a[min_index]=temp

Pseudocode for Shell Sort:

Algorithm shell (a, n, inc, n_inc)

// a – unsorted array, n – size of array, inc – array storing increment values, n_inc - size of array increments

Pre: Unsorted list of length n.

Post: Sorted list in ascending order of length n

1. for(increment=0; increment < n_inc; increment++)

    //span is the size of increment

    1. span = inc[increment]

    2. for(j = span; j<n ; j++)

    //inserts element a[j] into its proper position within subfile

        // sorting

        1. y = a[j]

        2. for(k = j-span; (k>=0 && y<a[k]); k= k-span)

            1. a[k+span] = a[k]

        3. a[k+span] = y;

Pseudo code for Quick Sort:

int partition (a, beg, end)

// Places pivot element piv at its proper position; elements

before it are less than it & after it are greater than it

1. piv = a[beg]
2. up = end
3. down = beg
4. while (down < up)

a. .while((a[down] <= piv) && (down<end))

i.down=down + 1

b. while(a[up]>piv)

i..up=up-1

c. .if (down<up)

i.swap (a[down], a[up])

5. .swap(a[beg], a[up])

6. .return up

Algorithm sort (a, beg, end)

// a - array to be sorted, beg - starting index of array to be sorted, end - ending index of array to be sorted

Pre: Unsorted list a of length n.

Post: Sorted list in ascending order of length n

1. if (beg < end)

a. j = partition(a, beg, end)

b. sort(a, beg, j-1)

c. sort (a, j+1, end)

2. Else

a. return

Pseudo code for Merge Sort:

```
Algorithm MergeSort(low, high)
// a[low : high] is a global array to be sorted.
// Small(P) is true if there is only one element
// to sort. In this case the list is already sorted.
{
    if (low < high) then  // If there are more than one element
    {
        // Divide P into subproblems.
            // Find where to split the set.
                mid := ⌊(low + high)/2⌋;
        // Solve the subproblems.
            MergeSort(low, mid);
            MergeSort(mid + 1, high);
        // Combine the solutions.
            Merge(low, mid, high);
    }
}
```

```
Algorithm Merge(low, mid, high)
// a[low : high] is a global array containing two sorted
// subsets in a[low : mid] and in a[mid + 1 : high]. The goal
// is to merge these two sets into a single set residing
// in a[low : high]. b[ ] is an auxiliary global array.
{
    h := low; i := low; j := mid + 1;
    while ((h ≤ mid) and (j ≤ high)) do
    {
        if (a[h] ≤ a[j]) then
        {
            b[i] := a[h];h := h + 1;
        }
        else
        {
            b[i] := a[j]; j := j + 1;
        }
        i := i + 1;
    }
    if (h > mid) then
        for k := j to high do
        {
            b[i] := a[k]; i := i + 1;
        }
    else
        for k := h to mid do
        {
            b[i] := a[k]; i := i + 1;
        }
    for k := low to high do a[k] := b[k];
}
```

1)Bubble Sort:

Program:

```
package BubbleSort;
import java.util.Scanner;
public class BubbleSort {
	static void bubbleSort(int[] a,int n) {
```

```
		int temp = 0,i;
		for(i=0;i<n;i++) {
			for(int j = 1;j<(n-i);j++) {
				if(a[j-1]>a[j]) {
					temp = a[j-1];
					a[j-1]=a[j];
					a[j] = temp;
				}
			}
		}
		System.out.println("Array After Bubble sort");
		for(i = 0;i<n;i++) {
			System.out.println(a[i]+" ");
		}
	}
	public static void main(String[] args) {
		int[] a = new int[10];
		int n,i;

		Scanner sc = new Scanner(System.in);
	    System.out.println("ROLL NO: 158");
		System.out.println("Enter Array size");
		n = sc.nextInt();

		System.out.println("Enter Array element");
		for(i = 0;i<n;i++) {
			a[i] = sc.nextInt();
		}

		bubbleSort(a,n);
sc.close();
```

```
        }
}
```

Output:

```
Problems   @ Javadoc   Declaration   Console ×
<terminated> BubbleSort (1) [Java Application] C:\Program Files\Java\jdk-21\bin\javaw.exe  (18-Oct-2024, 10
ROLL NO: 158
Enter Array size
6
Enter Array element
345
157
26
579
168
94
Array After Bubble sort
26
94
157
168
345
579
```

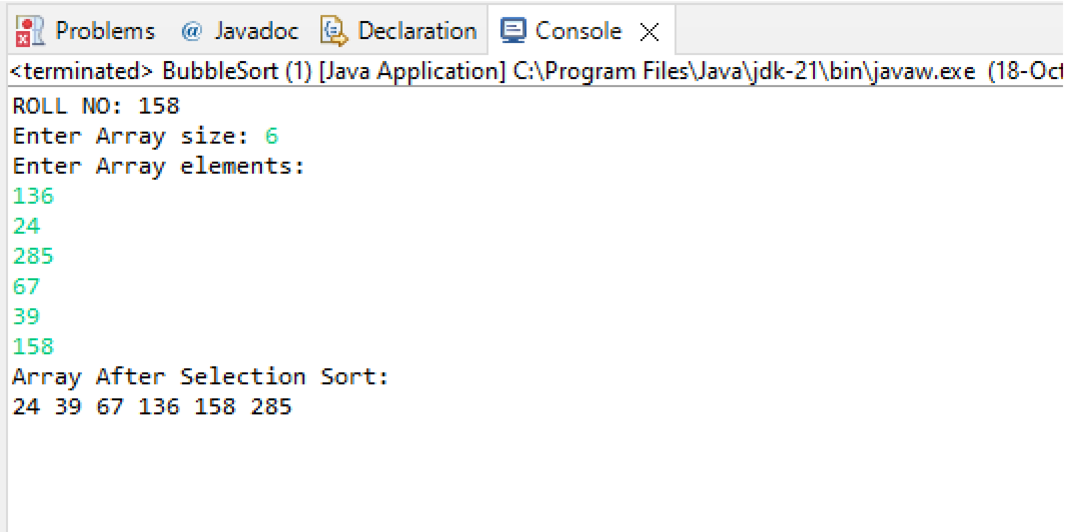
2)Selection Sort:

Code:

```
package sortingAlgos;
import java.util.Scanner;
public class selectionSort {
  static void selectionSort(int[] a, int n) {
      int temp, i;
      for (i = 0; i < n - 1; i++) {
          int min_index = i;
          for (int j = i + 1; j < n; j++) {
              if (a[j] < a[min_index]) {
                  min_index = j;
              }
          }
```

```
        if (min_index != i) {
          // Swap elements
          temp = a[min_index];
          a[min_index] = a[i];
          a[i] = temp;
        }
      }
      System.out.println("Array After Selection Sort:");
      for (i = 0; i < n; i++) {
        System.out.print(a[i] + " ");
      }
      System.out.println();
    }
    public static void main(String[] args) {
      int[] a;
      int n, i;
      Scanner sc = new Scanner(System.in);
      System.out.println("ROLL NO: 158");
      System.out.print("Enter Array size: ");
      n = sc.nextInt();

      a = new int[n];

      System.out.println("Enter Array elements:");
      for (i = 0; i < n; i++) {
        a[i] = sc.nextInt();
      }
      selectionSort(a, n);
      sc.close();
    }
  }
```

Output:



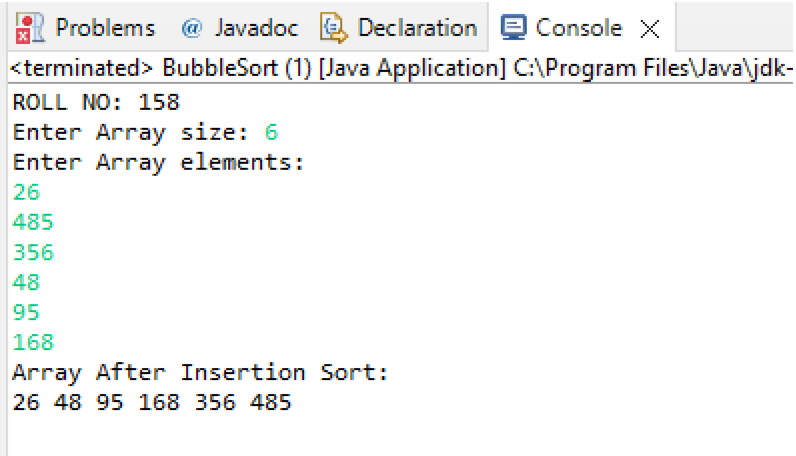
3)Insertion Sort:

Code:

```
package sortingAlgos;

import java.util.Scanner;

public class InsertionSort {


        public static void InsertionSort(int[] a) {

                for (int i = 1; i < a.length; i++) {

      int key = a[i];

      int j = i - 1;

      while (j >= 0 && a[j] > key) {

        a[j + 1] = a[j];

        j--;

      }

      a[j + 1] = key;

    }

                System.out.println("Array After Insertion Sort:");

    int i;
```

```
                for (i = 0; i < a.length; i++) {
        System.out.print(a[i] + " ");
    }
    System.out.println();
        }
        public static void main(String[] args) {
                int[] a;
    int n, i;
    Scanner sc = new Scanner(System.in);
    System.out.println("ROLL NO: 158");
    System.out.print("Enter Array size: ");
    n = sc.nextInt();

    a = new int[n];

    System.out.println("Enter Array elements:");
    for (i = 0; i < n; i++) {
        a[i] = sc.nextInt();
    }
    InsertionSort(a);
    sc.close();
        }
}
```

Output:



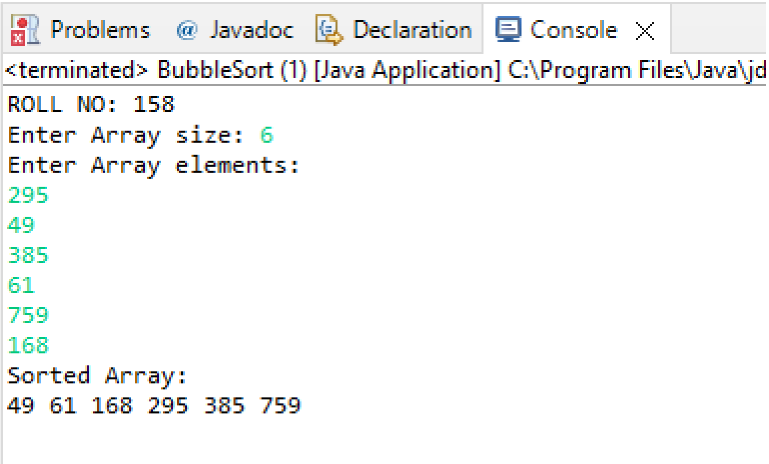
4)Shell Sort:

Code:

```
package sortingAlgos;
import java.util.Scanner;
public class shellSort {
  public static void shellSort(int[] a, int n, int[] inc, int n_inc) {
     for (int increment = 0; increment < n_inc; increment++) {
        int span = inc[increment];
        for (int j = span; j < n; j++) {
           int y = a[j];
           int k;
           for (k = j - span; (k >= 0 && y < a[k]); k -= span) {
              a[k + span] = a[k];
           }
           a[k + span] = y;
        }
     }
  }
  public static void main(String[] args) {
     int[] a;
```

```java
        int n, i;
        Scanner sc = new Scanner(System.in);
        System.out.println("ROLL NO: 158");
        System.out.print("Enter Array size: ");
        n = sc.nextInt();
        a = new int[n];
        System.out.println("Enter Array elements:");
        for (i = 0; i < n; i++) {
            a[i] = sc.nextInt();
        }
        // Define an array of increments for Shell Sort
        int[] increments = {5, 3, 1};

        // Call the shellSort method with correct arguments
        shellSort(a, a.length, increments, increments.length);

        // Display the sorted array
        System.out.println("Sorted Array:");
        for (i = 0; i < n; i++) {
            System.out.print(a[i] + " ");
        }
        sc.close();
    }
}
```

Output:



5)Quick Sort

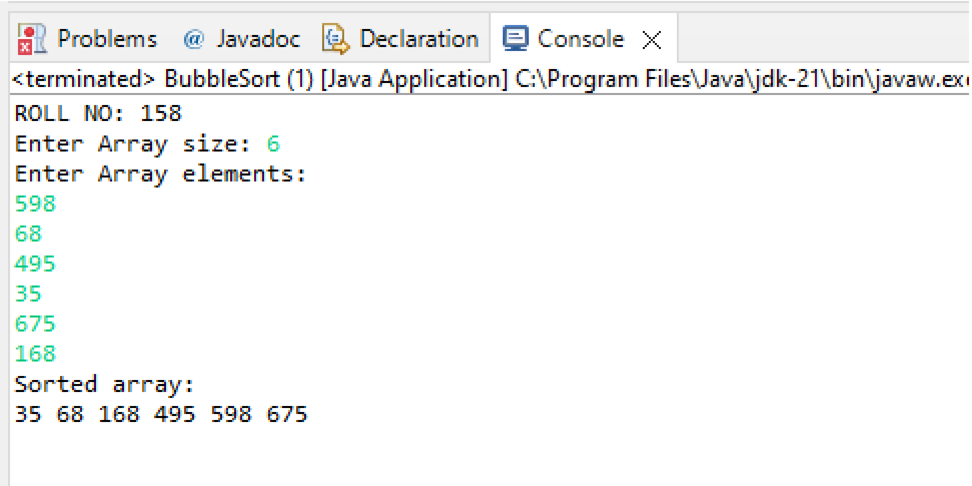
Code:

```
public static int quickPartition(int[] a, int beg, int end) {
    int pvt = a[beg];
    int down = beg;
    int up = end;
    int temp;
    while (down < up) {

      while (a[down] <= pvt && down < end) {
        down++;
      }

      while (a[up] > pvt) {
        up--;
      }

      if (down < up) {
        temp = a[down];
        a[down] = a[up];
        a[up] = temp;
      }
```

```
    }

    temp = a[beg];
    a[beg] = a[up];
    a[up] = temp;
    return up;
}

public static void sort(int[] a, int beg, int end) {
    if (beg < end) {
        int j = quickPartition(a, beg, end);
        sort(a, beg, j - 1);
        sort(a, j + 1, end);
    }
}
public static void main(String[] args) {
    int[] a;
    int n, i;
    Scanner sc = new Scanner(System.in);
    System.out.println("ROLL NO: 158");
    System.out.print("Enter Array size: ");
    n = sc.nextInt();
    a = new int[n];
    System.out.println("Enter Array elements:");
    for (i = 0; i < n; i++) {
        a[i] = sc.nextInt();
    }
    sort(a, 0, a.length - 1);
    System.out.println("Sorted array:");
    for (i = 0; i < n; i++) {
        System.out.print(a[i] + " ");
```

```
    }
    sc.close();
  }
}
```

Output:



```
Problems  @ Javadoc  Declaration  Console
<terminated> BubbleSort (1) [Java Application] C:\Program Files\Java\jdk-21\bin\javaw.ex
ROLL NO: 158
Enter Array size: 6
Enter Array elements:
598
68
495
35
675
168
Sorted array:
35 68 168 495 598 675
```

6)Merge Sort:

Code:

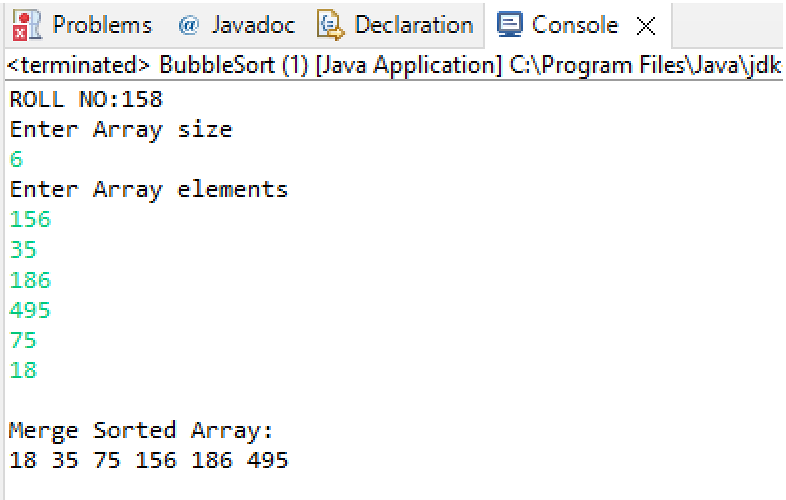
```
package sortingAlgos;
import java.util.Scanner;
public class mergeSort {
        private static void merge(int[] arr, int low, int middle, int high) {

    int n1 = middle - low + 1;
    int n2 = high - middle;
    int[] leftArray = new int[n1];
    int[] rightArray = new int[n2];
    for (int i = 0; i < n1; i++) {
```

```
            leftArray[i] = arr[low + i];
        }
        for (int j = 0; j < n2; j++) {
            rightArray[j] = arr[middle + 1 + j];
        }
        int i = 0, j = 0;
        int k = low;
        while (i < n1 && j < n2) {
            if (leftArray[i] <= rightArray[j]) {
                arr[k] = leftArray[i];
                i++;
            } else {
                arr[k] = rightArray[j];
                j++;
            }
            k++;
        }
        while (i < n1) {
            arr[k] = leftArray[i];
            i++;
            k++;
        }
        while (j < n2) {
            arr[k] = rightArray[j];
            j++;
            k++;
        }
    }
    private static void sort(int[] arr, int low, int high) {
        if (low < high) {
            int middle = (low + high) / 2;
```

```
      sort(arr, low, middle);
      sort(arr, middle + 1, high);
      merge(arr, low, middle, high);
    }
  }
  private static void printArray(int[] arr) {
    for (int num : arr) {
      System.out.print(num + " ");
    }
    System.out.println();
  }
  public static void main(String[] args) {
        int[] a;
                int n, i;

                Scanner sc = new Scanner(System.in);

                System.out.println("ROLL NO:158");
                System.out.println("Enter Array size");
                n = sc.nextInt();

                // Initialize the array with the given size
                a = new int[n];

                System.out.println("Enter Array elements");
                for(i = 0; i < n; i++) {
                        a[i] = sc.nextInt();
                }

    sort(a, 0, a.length - 1);
    System.out.println("\nSorted Array:");
```

```
        printArray(a);
        sc.close();
    }
}
```

Output:



Conclusion:

- Thus we have studied and implemented bubble sort, insertion sort , selection sort,

Shell and radix sort.

- The Time complexity for Bubble, Insertion and selection sort are

Algorithm	**Time complexity**		
	Best	Average	worst
Bubble sort	O(n)	O(n^2)	O(n^2)
Insertion Sort	O(n)	O(n^2)	O(n^2)
Selection Sort	O(n^2)	O(n^2)	O(n^2)

- Shell Sort is a comparison based sorting. Time complexity of Shell Sort depends on gap sequence.

- Radix Sort is an efficient non-comparison based sorting algorithm

Practical 3 - To implement hashing methods and collision resolution techniques

Aim: To implement hashing methods and collision resolution techniques

1. Modulo Division
2. Digit Extraction
3. Fold shift
4. Fold Boundary
5. Linear Probe for Collision Resolution

Objectives:

1. Learn how to map a large amount of data to a smaller table using a “hash function”
2. Learn to how to solve collision using Linear Probing

Theory:

Modulo – Division Method:

Address = key MODULO list size + 1

Digit Extraction:

Selected digits are extracted from the key and used as the address.

Fold Shift : key is divided into number of parts say k1,k2,…..,kn where each parts has the same number of digits except the last part , which can have lesser digits.Add all these parts and ignore last carry.

For eg. If Key = 123456789

123
+ 456
789
1368

Discard 1 so the address is **368**

Fold Boundary: left and right numbers are folded on a fixed boundary between them and the center number. These results in two outside values are being reversed.

For eg. If Key = 123-456-789

```
    321
    456
+   987
   1764    Discard 1   so the address is : 764
```

Code:

```
package adsa_hashing;
import java.util.*;
import java.util.Scanner;
public class New_hashing {
 long[] givenkeys = new long[5];
 long[] list = new long[100];
 // Method to accept keys from the user
 public void accept() {
    make_null();
    Scanner sc = new Scanner(System.in);
    for (int i = 0; i < 5; i++) {
       System.out.println("Enter key:");
       givenkeys[i] = sc.nextLong();
    }
 }
 // Method to initialize the list to 0
 public void make_null() {
    for (int i = 0; i < 100; i++) {
       list[i] = 0;
    }
 }
 // Method to print the list array
 public void print() {
```

```java
    for (int i = 0; i < 100; i++) {
        if (list[i] != 0) {
            System.out.println("List[" + i + "]=" + list[i]);
        }
    }
}
// Modular Division Hashing Method
public void modular_division() {
    System.out.println("Enter 4 digit keys");
    accept();
    for (int i = 0; i < 4; i++) {
        int index = (int) ((givenkeys[i] % 100) + 1);
        if (list[index] == 0) {
            list[index] = givenkeys[i];
        } else {
            int temp = index;
            while (list[temp] != 0) {
                temp++;
            }
            list[temp] = givenkeys[i];
        }
    }
    print();
}
// Digit Extraction Hashing Method
public void digit_extraction() {
    System.out.println("Enter 3-digit keys");
    accept();
    Scanner sc = new Scanner(System.in);
    int pos1, pos2;
    System.out.println("Enter 2 positions:");
```

```
pos1 = sc.nextInt();
pos2 = sc.nextInt();
for (int i = 0; i < 4; i++) {
    int add = 0;
    int d1 = (int) (givenkeys[i] / 100);
    int d2 = (int) ((givenkeys[i] / 10) % 10);
    int d3 = (int) (givenkeys[i] % 10);
    // Switch case for position 1
    switch (pos1) {
        case 1:
            add = add + (d1 * 10);
            break;
        case 2:
            add = add + (d2 * 10);
            break;
        case 3:
            add = add + (d3 * 10);
            break;
    }
    // Switch case for position 2
    switch (pos2) {
        case 1:
            add = add + d1;
            break;
        case 2:
            add = add + d2;
            break;
        case 3:
            add = add + d3;
            break;
    }
```

```
        if (list[add] == 0) {
            list[add] = givenkeys[i];
        } else {
            int temp = add;
            while (list[temp] != 0) {
                temp++;
            }
            list[temp] = givenkeys[i];
        }
    }
    print();
}
public void fold_shift() {
        System.out.println("Enter 4-digit values");
        accept();
        for(int i =0;i<5;i++) {
                int p1 =(int)(givenkeys[i]/100);
                int p2 =(int)(givenkeys[i]/100);

                int index = (p1 + p2)%100;
                if(list[index]==0)
                        list[index]=givenkeys[i];
                else {
                        int temp = p1 + p2;
                        while(list[temp]!=0)
                                temp++;
                        list[temp] = givenkeys[i];
                }
        }
        print();
}
```

```
public void fold_boundary() {
        make_null();
        System.out.println("Enter 4-Digit Keys");
        accept();
        for(int i=0;i<5;i++) {
                int n1 = (int)(givenkeys[i]/100);
                n1 = (n1%10)* 10 + (n1/10);
                int n2 = (int)(givenkeys[i]/100);
                n2 = (n2%10)* 10 + (n2/10);

                int index = (n1 + n2)% 100;

                if(list[index]==0)
                        list[index] = givenkeys[i];
                else {
                        int temp = index;
                        while(list[temp]!=0)
                                temp = (temp +1)% 100;
                        list[temp] = givenkeys[i];
                }
        }
        print();
}
// Main method with menu-driven interface
public static void main(String[] args) {
        System.out.println("ROLL NO: 158");
        Scanner sc = new Scanner(System.in);
        New_hashing h = new New_hashing();
        int ch;
        do {
          System.out.println("\n1. Modular Division");
```

```
            System.out.println("2. Digit Extraction");
            System.out.println("3. Fold Shift");
            System.out.println("4. Fold Boundary");
            System.out.println("5. Exit");
            System.out.println("Enter your choice:");
            ch = sc.nextInt();
            switch (ch) {
              case 1:
                h.modular_division();
                break;
              case 2:
                h.digit_extraction();
                break;
              case 3:
                h.fold_shift();
                break;
              case 4:
                h.fold_boundary();
                break;
              case 5:
                System.out.println("Exiting program...");
                sc.close();  // Ensure Scanner is closed before exiting
                System.exit(0);
            }
          } while (ch != 3);
          sc.close();
        }
}
```

1)Modulo:

```
ROLL NO: 158

1. Modular Division
2. Digit Extraction
3. Fold Shift
4. Fold Boundary
5. Exit
Enter your choice:
1
Enter 4 digit keys
Enter key:
5687
Enter key:
8754
Enter key:
2134
Enter key:
5135
Enter key:
4568
List[35]=2134
List[36]=5135
List[55]=8754
List[88]=5687
```

2) Digit Extraction:

```
ROLL NO: 158

1. Modular Division
2. Digit Extraction
3. Fold Shift
4. Fold Boundary
5. Exit
Enter your choice:
2
Enter 3-digit keys
Enter key:
234
Enter key:
678
Enter key:
987
Enter key:
321
Enter key:
432
Enter 2 positions:
1
4
List[20]=234
List[30]=321
List[60]=678
List[90]=987
```

3) Fold_Shift:

```
ROLL NO: 158

1. Modular Division
2. Digit Extraction
3. Fold Shift
4. Fold Boundary
5. Exit
Enter your choice:
3
Enter 4-digit values
Enter key:
7890
Enter key:
7654
Enter key:
3456
Enter key:
8765
Enter key:
2345
List[46]=2345
List[52]=7654
List[56]=7890
List[68]=3456
List[74]=8765
```

4) Fold_Boundary:

```
ROLL NO: 158

1. Modular Division
2. Digit Extraction
3. Fold Shift
4. Fold Boundary
5. Exit
Enter your choice:
4
Enter 4-Digit Keys
Enter key:
6789
Enter key:
8907
Enter key:
4563
Enter key:
2341
Enter key:
6785
List[8]=4563
List[52]=6789
List[53]=6785
List[64]=2341
List[96]=8907
```

<u>Conclusion</u>: Map a large amount of data to a smaller table using a “hash function” and learn to how to solve collision using Linear Probing

<u>Practical 4 - To implement different operation on stack using array</u>

<u>Aim:</u> To implement different operation on stack using array

1. Push()
2. Pop()
3. isfull()
4. isempty()
5. count()

6. display()

Objectives:

1. Learn how to implement different operation on stack using array

Theory:

A stack is an ordered collection of items into which new items may be inserted and items may be deleted at one end called TOP of the stack.

A stack is a homogeneous collection of items of any one type.

Data can be added or removed from only the top.

Last In, First Out (LIFO)

Operations perform on stack:

- **Push :** Place an item onto the stack. If there is no place for new item, stack is in overflow state.

Algorithm:

Algorithm :push(S, TOP, X): This algorithm insert element x to the top of the stack which is represented by array S containing N elements with pointer TOP denoting the top most element in the stack.

1. [check for stack overflow]

   if TOP >= N-1

   write[stack overflow]

   return

2. [Increment TOP]

   TOP = TOP+1

3. [Insert element]

   S[TOP]=X

4. [finished]

   return

- **Pop :**Return the item at the top of the stack and then remove it. If pop is called when stack is empty, it is in an underflow state.

Algorithm :pop(S, TOP): This algorithm remove top most element from top of the stack which is represented by array S containing N elements with pointer TOP denoting the top most element in the stack.

1. [check for stack underflow]

if TOP = -1

write[stack underflow on POP]

return

2. [Decrement TOP Pointer]

TOP = TOP-1

3. [return top element from stack]

return(S[TOP+1]

- **isfull:** Tells if the stack is full or not.

Algorithm :isfull(S, TOP, N): This algorithm check whether stack is full . stack S containing N elements with pointer TOP denoting the top most element in the stack.

1. [check for stack overflow]

if TOP > =N-1

write[stack full]

return

- **isEmpty** : Tells if the stack is empty or not.

Algorithm :isempty l(S, TOP, N): This algorithm check whether stack is full . stack S containing N elements with pointer TOP denoting the top most element in the stack.

1. [check for stack overflow]

if TOP ==-1

write[stack empty]

return

- **Count:** The number of items in the stack.

Algorithm :count(S, TOP): This algorithm count number of elements present in stack which is represented by array S containing N elements with pointer TOP denoting the top most element in the stack.

1. [check for empty stack]

if TOP==-1

count=0

return count

2. For i=0 to top

Count=count+1

3. Return count

- **Change():**

Algorithm :change(S, TOP,X i): This algorithm display elements present in stack from top of the stack S containing N elements with pointer TOP denoting the top most element in the stack.

1. [check for empty stack]

   if TOP==-1

   display(“stack is empty”)

2. For i=top to 0

   Display (s[i])

3. [finish]

return

Code:

```
package Linear_DS;
import java.util.Scanner;
public class Stack_DS {
  int TOP = -1;  // Pointer to the top of the stack, initially -1 (empty stack)
  int N;  // Maximum size of the stack
  int[] stack;  // Stack array
  // Constructor to initialize the stack
  public Stack_DS(int size) {
     N = size;
     stack = new int[N];
  }
  // Push operation with overflow check
```

```java
public void push(int X) {
    if (isFull()) {
        System.out.println("Stack Overflow. Cannot push " + X);
        return;
    }
    TOP = TOP + 1;
    stack[TOP] = X;
    System.out.println(X + " pushed to stack.");
}
// Pop operation with underflow check
public void pop() {
    if (isEmpty()) {
        System.out.println("Stack Underflow on POP. The stack is empty.");
        return;
    }
    int poppedElement = stack[TOP];
    TOP = TOP - 1;
    System.out.println("Popped element: " + poppedElement);
}
// Check if the stack is full
public boolean isFull() {
    return TOP >= N - 1;
}
// Check if the stack is empty
public boolean isEmpty() {
    return TOP == -1;
}
// Count the number of items in the stack
public int count() {
    return TOP + 1; // Because TOP is zero-indexed
}
```

```java
// Change (Display) all elements from top to bottom
public void change() {
    if (isEmpty()) {
        System.out.println("Stack is empty.");
    } else {
        System.out.println("Stack elements from top to bottom:");
        for (int i = TOP; i >= 0; i--) {
            System.out.println(stack[i]);
        }
    }
}
// Print the current state of the stack
public void printStack() {
    if (isEmpty()) {
        System.out.println("Stack is empty.");
    } else {
        System.out.println("Stack elements: ");
        for (int i = 0; i <= TOP; i++) {
            System.out.println(stack[i]);
        }
    }
}
// Main method with infinite loop and switch cases
public static void main(String[] args) {
    Scanner sc = new Scanner(System.in);
    System.out.println("Enter the size of the stack:");
    int size = sc.nextInt();
    Stack_DS stackOps = new Stack_DS(size);
    while (true) {
        System.out.println("\nChoose an operation:");
        System.out.println("1. Push");
```

```
System.out.println("2. Pop");
System.out.println("3. Check if Full");
System.out.println("4. Check if Empty");
System.out.println("5. Count items in Stack");
System.out.println("6. Change (Display all elements)");
System.out.println("7. Print Stack");
System.out.println("8. Exit");
System.out.print("Enter your choice: ");
int choice = sc.nextInt();
switch (choice) {
  case 1:
    System.out.print("Enter value to push: ");
    int value = sc.nextInt();
    stackOps.push(value);
    break;
  case 2:
    stackOps.pop();
    break;
  case 3:
    if (stackOps.isFull()) {
      System.out.println("The stack is full.");
    } else {
      System.out.println("The stack is not full.");
    }
    break;
  case 4:
    if (stackOps.isEmpty()) {
      System.out.println("The stack is empty.");
    } else {
      System.out.println("The stack is not empty.");
    }
```

```
                break;
            case 5:
                System.out.println("The number of elements in the stack: " + stackOps.count());
                break;
            case 6:
                stackOps.change();
                break;
            case 7:
                stackOps.printStack();
                break;
            case 8:
                System.out.println("Exiting...");
                sc.close();
                System.exit(0);
            default:
                System.out.println("Invalid choice. Please try again.");
        }
      }
    }
}
```

Output:

1)Push

```
Roll No.: 158
Choose an operation:
1. Push
2. Pop
3. Check if Full
4. Check if Empty
5. Count items in Stack
6. Change (Display all elements)
7. Print Stack
8. Exit
Enter your choice: 1
Enter value to push: 34
34 pushed to stack.
```

2) Pop

```
Roll No.: 158
Choose an operation:
1. Push
2. Pop
3. Check if Full
4. Check if Empty
5. Count items in Stack
6. Change (Display all elements)
7. Print Stack
8. Exit
Enter your choice: 2
Popped element: 34
```

3) Check if Full

```
Roll No.: 158
Choose an operation:
1. Push
2. Pop
3. Check if Full
4. Check if Empty
5. Count items in Stack
6. Change (Display all elements)
7. Print Stack
8. Exit
Enter your choice: 3
The stack is full.
```

4) Check if Empty

```
Roll No.: 158
Choose an operation:
1. Push
2. Pop
3. Check if Full
4. Check if Empty
5. Count items in Stack
6. Change (Display all elements)
7. Print Stack
8. Exit
Enter your choice: 4
The stack is not empty.
```

5) Count items in Stack

```
Roll No.: 158
Choose an operation:
1. Push
2. Pop
3. Check if Full
4. Check if Empty
5. Count items in Stack
6. Change (Display all elements)
7. Print Stack
8. Exit
Enter your choice: 5
The number of elements in the stack: 4
```

6) Change

```
Roll No.: 158
Choose an operation:
1. Push
2. Pop
3. Check if Full
4. Check if Empty
5. Count items in Stack
6. Change (Display all elements)
7. Print Stack
8. Exit
Enter your choice: 6
Stack elements from top to bottom:
39
75
24
12
```

7) Print

```
Roll No.: 158
Choose an operation:
1. Push
2. Pop
3. Check if Full
4. Check if Empty
5. Count items in Stack
6. Change (Display all elements)
7. Print Stack
8. Exit
Enter your choice: 7
Stack elements:
12
24
75
39
```

<u>**Conclusion**:</u> Stack is a linear data structure which works on Last In First Out (LIFO) principle.

Practical 5

Aim: Evaluation of postfix expression and balancing of parenthesis

To implement applications of stack:

1. Evaluation of postfix expressions

2. Balancing of parenthesis

Objectives:

1. Learn how to apply stack logic to evaluate postfix expression and checking parenthesis are balanced in given expression

Theory: Stack using Array Implementation

1. Postfix Expressions Evaluation

The expression of the form "a b operator" (ab+) i.e., when a pair of operands is followed by an operator. Iterate the expression from left to right and keep on storing the operands into a stack. Once an operator is received, pop the two topmost elements and evaluate them and push the result in the stack again.

1. Create an empty stack that will contain operands.

2. Take one by one token from the left to right.

1. If a token is an operand, push it onto the stack.

1. If token is an operator op

2. Pop the top item from the stack as operand2.

3. Pop again the top item from the stack as operand1.

4. Perform operation operand1 op operand2.

5. Push the result back to stack.

3. When all tokens in input expression are processed stack should contain a single item, which is

the value of expression

2. Balancing Parenthesis

The idea is to put all the opening brackets in the stack. Whenever you hit a closing bracket, search if the top of the stack is the opening bracket of the same nature. If this holds then pop the stack and continue the iteration. In the end if the stack is empty, it means all brackets are balanced or well-formed. Otherwise, they are not balanced.

1. Declare a character stack S.

2. Now traverse the expression string exp.

1. If the current character is a starting bracket ('(' or '{' or '[') then push it to stack.

2. If the current character is a closing bracket (')' or '}' or ']') then pop from stack and if

the popped character is the matching starting bracket then fine else brackets are not balanced.

3. After complete traversal, if there is some starting bracket left in the stack then “not balanced”.

Program:

1. **1. Postfix Expressions Evaluation**

```
package Linear_DS;
import java.util.Stack;
public class PostFixEvaluator {
 public static int evaluatePostfix(String expression) {

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



    for (int i = 0; i < expression.length(); i++) {
      char token = expression.charAt(i);

      if (Character.isDigit(token)) {
        stack.push(token - '0');
      } else {

        int operand2 = stack.pop();
        int operand1 = stack.pop();
        int result = 0;

        switch (token) {
          case '+':
            result = operand1 + operand2;
            break;
          case '-':
```

```
                result = operand1 - operand2;
                break;
              case '*':
                result = operand1 * operand2;
                break;
              case '/':
                result = operand1 / operand2;
                break;
            }

            stack.push(result);
          }
        }



        return stack.pop();
      }
      public static void main(String[] args) {
        String expression = "231*+9-";
            System.out.println("Roll No: 158");
       System.out.println("The result of the postfix expression '" + expression + "' is: " +
    evaluatePostfix(expression));
      }
    }
```

Output:

```
Roll No: 158
The result of the postfix expression '231*+9-' is: -4
```

Program:

2. Balancing Parenthesis

```
package Linear_DS;

import java.util.Stack;

public class ParenthesisBalancer {

 public static boolean isBalanced(String expression) {


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



    for (int i = 0; i < expression.length(); i++) {

      char current = expression.charAt(i);



      if (current == '(' || current == '{' || current == '[') {

        stack.push(current);

      }


      else if (current == ')' || current == '}' || current == ']') {


        if (stack.isEmpty() || !isMatchingPair(stack.pop(), current)) {

          return false;

        }

      }

    }



    return stack.isEmpty();

 }


 private static boolean isMatchingPair(char open, char close) {

    return (open == '(' && close == ')') ||
```

```
          (open == '{' && close == '}') ||
          (open == '[' && close == ']');
 }
 public static void main(String[] args) {
    String expression = "{[()]}";
    System.out.println("Roll no. 158");
    System.out.println("The expression '" + expression + "' is " + (isBalanced(expression) ?
"balanced" : "not balanced"));

    expression = "{[(])}";
    System.out.println("The expression '" + expression + "' is " + (isBalanced(expression) ?
"balanced" : "not balanced"));
 }
}
```

Output:

```
Roll no. 158
The expression '{[()]}' is balanced
The expression '{[(])}' is not balanced
```

Conclusion: Applied stack logic to evaluate postfix expression and checking parenthesis are balanced in given expression.

Practical 6

Aim: To implement linear queue using array

1. enqueue
2. dequeue
3. count
4. display

Objectives:

1. Learn how to implement different operations on linear queue using array

Theory:

Algorithm : enqueue

QINSERT (Q,F,R,N,Y) : Given F and R , pointers to the front and rear elements of the queue , a queue Q consisting of N elements and y is an element which is inserted by this procedure at the rear of the queue . Initially F and R are set to zero.

1. [checking for overflow]

   If (R>=N)

   then write (" overflow")

   return

2. [Increment rear pointer]

   R=R+1

3. [Insert element]

   Q[R] = Y

4. [Is front pointer properly set]

   if F=0

   Then F= 1

   Return

Algorithm : Dequeue

QDELETE (Q,F,R) : Given F and R , pointers to the front and rear elements of the queue , This procedure deletes elements in front of the queue . Y is a temporary variable .

1. [checking for underflow]

   If (F==0)

   then write (" underflow")

   return

2. [Delete element]

   Y= Q[F]

3. [Queue empty]

   if F=R

Then F= R = 0

Else F= F + 1 (increment front pointer)

4. [Return element]

Return(Y)

Algorithm : count

QCOUNT (Q,F,R) : Given F and R , pointers to the front and rear elements of the queue , a queue Q consisting of N elements and count is a temporary variable containing no of elements in the queue. This procedure returns 0 if the queue is empty otherwise returns count.

1. [checking for underflow]

If (F==0)

then write (" Queue is empty ")

count=0

return count

2. else

for i=front to rear

Count =count +1

return count

Algorithm : display

Qdisplay (Q,F,R) : Given F and R , pointers to the front and rear elements of the queue , a queue Q consisting of N elements and count is a temporary variable containing no of elements in the queue. This procedure returns 0 if the queue is empty otherwise returns count.

2. [checking for underflow]

If (F==0)

then write (" Queue is empty ")

return

3. else

for i=front to rear

display (Q[i])

Program:

```
package Linear_DS;
import java.util.Scanner;
public class Queue_linear {
 private int[] Q;
 private int front;
 private int rear;
 private int size;
 // Constructor to initialize the queue with a given size
 public Queue_linear(int n) {
    size = n;
    Q = new int[size];
    front = 0;
    rear = 0;
 }
 // Enqueue operation: Insert element Y at the rear
 public void enqueue(int y) {
    if (rear >= size) {
       System.out.println("Overflow: Queue is full.");
       return;
    }
    Q[rear] = y;
    rear++;
    // Set front to 1 if this is the first element
    if (front == 0) {
       front = 1;
    }
```

```
}
// Dequeue operation: Remove and return element from the front
public int dequeue() {
   if (front == 0 || front > rear) {
      System.out.println("Underflow: Queue is empty.");
      return -1;
   }
   int y = Q[front - 1];
   // Adjust front and rear if queue is empty after dequeue
   if (front == rear) {
      front = 0;
      rear = 0;
   } else {
      front++;
   }
   return y;
}
// Check if the queue is empty
public boolean isEmpty() {
   return front == 0 || front > rear;
}
// Count operation: Return the number of elements in the queue
public int count() {
   if (isEmpty()) {
      return 0;
   }
   return rear - front + 1;
}
// Display operation: Print all elements in the queue from front to rear
public void display() {
   if (isEmpty()) {
```

```
            System.out.println("Queue is empty.");
            return;
        }
        System.out.print("Queue elements: ");
        for (int i = front - 1; i < rear; i++) {
            System.out.print(Q[i] + " ");
        }
        System.out.println();
    }
    // Main method to handle user interaction with queue operations
    public static void main(String[] args) {
        Scanner sc = new Scanner(System.in);
        System.out.println("Enter the size of the queue:");
        int size = sc.nextInt();
        Queue_linear queue = new Queue_linear(size);
        while (true) {
            System.out.println("\nChoose an operation:");
            System.out.println("1. Enqueue");
            System.out.println("2. Dequeue");
            System.out.println("3. Check if Queue is Empty");
            System.out.println("4. Count items in Queue");
            System.out.println("5. Display Queue");
            System.out.println("6. Exit");
            System.out.println("Roll No: 158");
            System.out.print("Enter your choice: ");
            int choice = sc.nextInt();
            switch (choice) {
                case 1:
                    System.out.print("Enter value to enqueue: ");
                    int value = sc.nextInt();
                    queue.enqueue(value);
```

```
            break;
          case 2:
            int dequeuedValue = queue.dequeue();
            if (dequeuedValue != -1) {
              System.out.println("Dequeued element: " + dequeuedValue);
            }
            break;
          case 3:
            if (queue.isEmpty()) {
              System.out.println("The queue is empty.");
            } else {
              System.out.println("The queue is not empty.");
            }
            break;
          case 4:
            System.out.println("The number of elements in the queue: " + queue.count());
            break;
          case 5:
            queue.display();
            break;
          case 6:
            System.out.println("Exiting...");
            sc.close();
            System.exit(0);
          default:
            System.out.println("Invalid choice. Please try again.");
        }
      }
    }
  }
```

Output:

1. Enqueue:

```
Enter the size of the queue:
5

Choose an operation:
1. Enqueue
2. Dequeue
3. Check if Queue is Empty
4. Count items in Queue
5. Display Queue
6. Exit
Roll No: 158
Enter your choice: 1
Enter value to enqueue: 68
```

2. Dequeue:

```
Choose an operation:
1. Enqueue
2. Dequeue
3. Check if Queue is Empty
4. Count items in Queue
5. Display Queue
6. Exit
Roll No: 158
Enter your choice: 2
Dequeued element: 68
```

3. Count:

```
Choose an operation:
1. Enqueue
2. Dequeue
3. Check if Queue is Empty
4. Count items in Queue
5. Display Queue
6. Exit
Roll No: 158
Enter your choice: 4
The number of elements in the queue: 4
```

4. Display

```
Choose an operation:
1. Enqueue
2. Dequeue
3. Check if Queue is Empty
4. Count items in Queue
5. Display Queue
6. Exit
Roll No: 158
Enter your choice: 5
Queue elements: 37 49 29 60
```

5. If empty

```
Choose an operation:
1. Enqueue
2. Dequeue
3. Check if Queue is Empty
4. Count items in Queue
5. Display Queue
6. Exit
Roll No: 158
Enter your choice: 3
The queue is not empty.
```

<u>Conclusion</u>: LINEAR queue is a linear data structure which works on First In First Out principle.