

Laboratory Assignment File
for

Data Structure and Algorithms

Master of Technology
in
Computer Science & Engineering

Submitted by

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May, 2026

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Assignment 1: Basic Programs

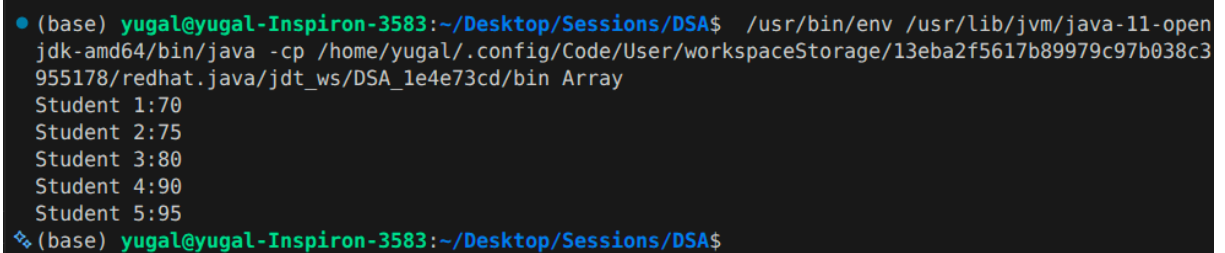
1.1 Hello World

```
1 public class Hello{
2     public static void main(String arg[]){
3         System.out.println("Hello");
4     }
5 }
```

1.2 Write a program to show Array

```
1 // Store and display the marks
2 public class Array{
3     public static void main(String... args){
4         int[] marks = {70,75,80,90,95};
5         for(int i=0;i<marks.length;i++){
6             // System.out.println("Student Marks: "+marks[i]);
7             System.out.println("Student " + (i+1) + ":"+marks[i]);
8         }
9     }
10 }
11 }
```

Output



```
• (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$ /usr/bin/env /usr/lib/jvm/java-11-open
jdk-amd64/bin/java -cp /home/yugal/.config/Code/User/workspaceStorage/13eba2f5617b89979c97b038c3
955178/redhat.java/jdt_ws/DSA_1e4e73cd/bin Array
Student 1:70
Student 2:75
Student 3:80
Student 4:90
Student 5:95
❏ (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$
```

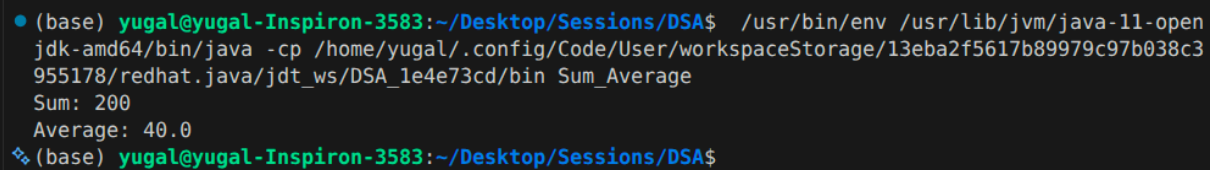
Figure 1: Program to show Array

1.3 Write a program to show sum and average

```
1 // Sum and average of array elements
2 class Sum_Average {
3
4     public static void main(String[] args){
5         int[] a = {20,30,40,50,60};
6         int sum = 0;
```

```
7
8     for(int x:a){
9         sum += x;
10    }
11    double average = (double) sum/a.length;
12
13    System.out.println("Sum: "+ sum);
14    System.out.println("Average: "+ average);
15 }
16 }
```

Output

A terminal window with a dark background. The prompt is '(base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA\$'. The command executed is '/usr/bin/env /usr/lib/jvm/java-11-openjdk-amd64/bin/java -cp /home/yugal/.config/Code/User/workspaceStorage/13eba2f5617b89979c97b038c3955178/redhat.java/jdt_ws/DSA_1e4e73cd/bin Sum_Average'. The output is 'Sum: 200' and 'Average: 40.0'. The prompt is '(base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA\$'.

```
• (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$ /usr/bin/env /usr/lib/jvm/java-11-openjdk-amd64/bin/java -cp /home/yugal/.config/Code/User/workspaceStorage/13eba2f5617b89979c97b038c3955178/redhat.java/jdt_ws/DSA_1e4e73cd/bin Sum_Average
Sum: 200
Average: 40.0
❖ (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$
```

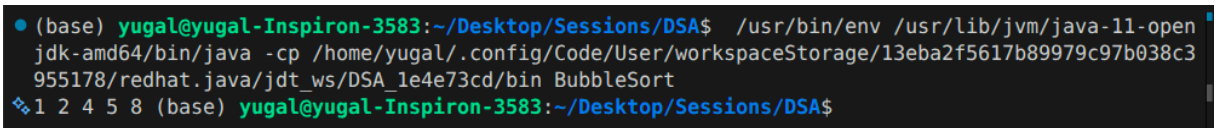
Figure 2: Program to show sum and average

Assignment 2: Sorting Algorithms

2.1 Write a program to show Bubble Sort

```
1 // Sorting of array in Bubble Sort
2 public class BubbleSort{
3     public static void main(String[] args){
4         int arr[] = {5,1,4,2,8};
5         for(int i=0; i<arr.length-1; i++){
6             for(int j=0; j<arr.length-i-1; j++){
7                 if(arr[j]>arr[j+1]){
8                     int temp = arr[j];
9                     arr[j] = arr[j+1];
10                    arr[j+1] = temp;
11                }
12            }
13        }
14        for(int num : arr){
15            System.out.print(num + " ");
16        }
17    }
18 }
```

Output



```
● (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$ /usr/bin/env /usr/lib/jvm/java-11-open
jdk-amd64/bin/java -cp /home/yugal/.config/Code/User/workspaceStorage/13eba2f5617b89979c97b038c3
955178/redhat.java/jdt_ws/DSA_1e4e73cd/bin BubbleSort
1 2 4 5 8 (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$
```

Figure 3: Program to show Bubble Sort

2.2 Write a program to show Insertion Sort

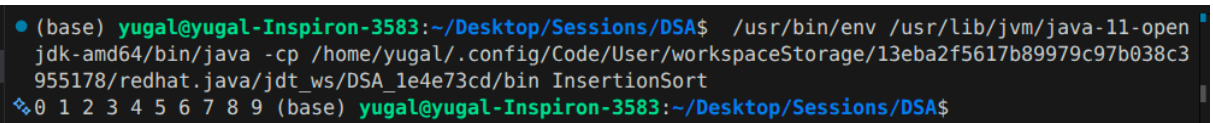
```
1 // Insertion Sort
2 public class InsertionSort {
3     public static void main(String[] args) {
4         int arr[] = {1,4,5,2,3,7,9,8,0,6};
5         for(int i = 1; i<arr.length; i++){
6             int key = arr[i];
7             int j = i-1;
8             while (j>=0 && arr[j]>key) {
9                 arr[j+1] = arr[j];
10                j--;
11            }
12        }
13    }
14 }
```

```

12         arr[j+1] = key;
13     }
14     for(int num : arr){
15         System.out.print(num + " ");
16     }
17 }
18 }

```

Output



```

• (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$ /usr/bin/env /usr/lib/jvm/java-11-open
jdk-amd64/bin/java -cp /home/yugal/.config/Code/User/workspaceStorage/13eba2f5617b89979c97b038c3
955178/redhat.java/jdt_ws/DSA_1e4e73cd/bin InsertionSort
❖ 0 1 2 3 4 5 6 7 8 9 (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$

```

Figure 4: Program to show Insertion Sort

2.3 Write a program to show Selection Sort

```

1 //Selection Sort
2 public class SelectionSort {
3     public static void main(String[] args) {
4         int arr[] = {3,5,2,6,-1,0,4,7,9,8,-2};
5
6         for(int i=0;i<arr.length-1;i++){
7             int minIndex = i;
8             for(int j = i+1; j<arr.length;j++){
9                 if(arr[j]<arr[minIndex]){
10                     minIndex = j;
11
12                 }
13             }
14             int temp = arr[minIndex];
15             arr[minIndex] = arr[i];
16             arr[i] = temp;
17         }
18         for(int num : arr){
19             System.out.print(num + " ");
20
21         }
22     }
23
24 }

```

Output

```
• (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$ /usr/bin/env /usr/lib/jvm/java-11-openjdk-amd64/bin/java -cp /home/yugal/.config/Code/User/workspaceStorage/13eba2f5617b89979c97b038c3955178/redhat.java/jdt_ws/DSA_1e4e73cd/bin SelectionSort
-2 -1 0 2 3 4 5 6 7 8 9 (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$
```

Figure 5: Program to show Selection Sort

2.4 Write a program to show Merge Sort

```
1 //Merge Sort : Divide and Conquer
2 import java.util.Arrays;
3
4 public class MergeSort {
5
6     // Main merge sort function
7     public static void mergeSort(int[] arr, int left, int right){
8         if(left < right){
9             int mid = left + (right-left)/2;
10            // Sort Left Half
11            mergeSort(arr, left, mid);
12            // Sort Right Half
13            mergeSort(arr, mid+1, right);
14            // Merge Both Halves
15            merge(arr, left, mid, right);
16        }
17    }
18
19    // Merge two sorted subarrays
20    public static void merge(int[] arr, int left, int mid, int right){
21        int n1 = mid-left+1;
22        int n2 = right-mid;
23        int[] l = new int[n1];
24        int[] r = new int[n2];
25
26        // Copy data to temp arrays
27        for(int i=0; i<n1; i++)
28            l[i] = arr[left+i];
29        for(int j=0; j<n2; j++)
30            r[j] = arr[mid+1+j];
31
32        int i = 0, j=0, k=left;
33
34        // Merge temp arrays back into array/arr
35        while (i<n1 && j<n2) {
```



```

36         if (l[i]<=r[j]) {
37             arr[k++] = l[i++];
38         }
39         else{
40             arr[k++] = r[j++];
41         }
42     }
43
44     // Copy remaining elements
45     while (i<n1) {
46         arr[k++] = l[i++];
47     }
48     while (j<n2) {
49         arr[k++] = r[j++];
50     }
51 }
52
53 // Driver Code
54 public static void main(String[] args) {
55
56     int[] arr = {38,27,43,3,9,82,10};
57     System.out.println("Before Sorting: ");
58     System.out.println(Arrays.toString(arr));
59
60     mergeSort(arr, 0, arr.length-1);
61
62     System.out.println("After Sorting: ");
63     System.out.println(Arrays.toString(arr));
64
65 }
66 }

```

Output

```

(base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$ cd /home/yugal/Desktop/Sessions/DSA ;
/usr/bin/env /usr/lib/jvm/java-11-openjdk-amd64/bin/java -cp /home/yugal/.config/Code/User/works
paceStorage/13eba2f5617b89979c97b038c3955178/redhat.java/jdt_ws/DSA_1e4e73cd/bin MergeSort
Before Sorting:
[38, 27, 43, 3, 9, 82, 10]
After Sorting:
[3, 9, 10, 27, 38, 43, 82]
(base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$

```

Figure 6: Program to show Merge Sort

2.5 Write a program to show Quick Sort

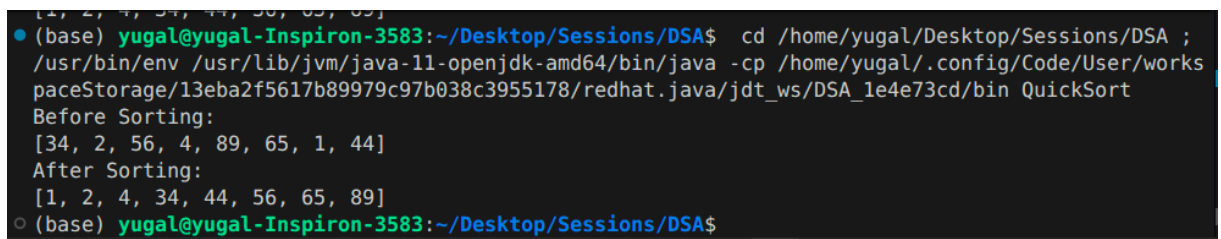
```

1      // Quick Sort : small -- pivot -- larger
2  import java.util.Arrays;
3
4  public class QuickSort {
5
6      // Main quick sort function
7      public static void quickSort(int[] arr, int low, int high){
8          if (low<high) {
9              int pivotIndex = partition(arr, low, high);
10
11              // Sort elements before and after partition
12              quickSort(arr, low, pivotIndex-1);
13              quickSort(arr, pivotIndex+1, high);
14          }
15      }
16
17      // Partition Function
18      public static int partition(int[] arr, int low, int high){
19          int pivot = arr[high]; // Choose last element as pivot
20          int i = low-1;
21          for(int j=low; j<high; j++){
22              if (arr[j]<pivot) {
23                  i++;
24
25                  // Swap arr[i] and arr[j]
26                  int temp = arr[i];
27                  arr[i] = arr[j];
28                  arr[j] = temp;
29              }
30          }
31
32          // Place pivot at correct position
33          int temp = arr[i+1];
34          arr[i+1] = arr[high];
35          arr[high] = temp;
36
37          return i+1;
38      }
39
40      // Driver code
41      public static void main(String[] args) {
42
43          int[] arr = {34,2,56,4,89,65,1,44};

```

```
44     System.out.println("Before Sorting: ");
45     System.out.println(Arrays.toString(arr));
46
47     quickSort(arr, 0, arr.length-1);
48     System.out.println("After Sorting: ");
49     System.out.println(Arrays.toString(arr));
50
51 }
52 }
```

Output



```
[1, 2, 4, 34, 44, 56, 65, 89]
(base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$ cd /home/yugal/Desktop/Sessions/DSA ;
/usr/bin/env /usr/lib/jvm/java-11-openjdk-amd64/bin/java -cp /home/yugal/.config/Code/User/workspaceStorage/13eba2f5617b89979c97b038c3955178/redhat.java/jdt_ws/DSA_1e4e73cd/bin QuickSort
Before Sorting:
[34, 2, 56, 4, 89, 65, 1, 44]
After Sorting:
[1, 2, 4, 34, 44, 56, 65, 89]
(base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$
```

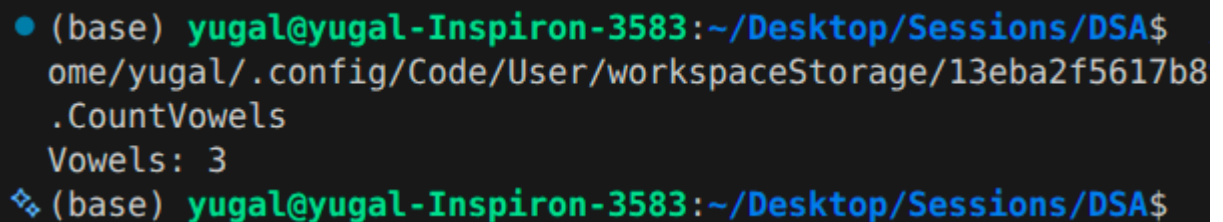
Figure 7: Program to show Quick Sort

Assignment 3: String

3.1 Write a program to Count Vowels in a String

```
1 package Strings;
2 // Count vowels name in String
3 public class CountVowels {
4     public static void main(String[] args) {
5         String str = "Eleven";
6         int count = 0;
7         for(int i=0; i<str.length();i++){
8             char ch = str.charAt(i);
9             if("AEIOUaeiou".indexOf(ch) != -1){
10                 count++;
11             }
12         }
13         System.out.println("Vowels: "+ count);
14     }
15 }
```

Output



```
• (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$
  ome/yugal/.config/Code/User/workspaceStorage/13eba2f5617b8
  .CountVowels
  Vowels: 3
❖ (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$
```

Figure 8: Output of Count Vowels Program

3.2 Palindrome String

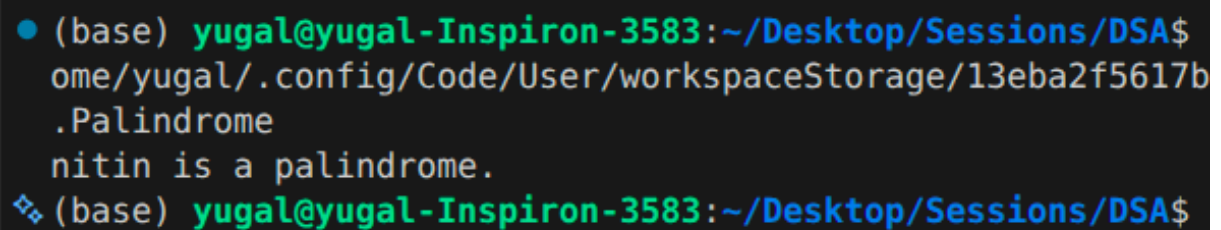
```
1 package Strings;
2 // Word is spelled in same way forward or backward. Eg: NITIN, MADAM
3 //Palindrome
4 public class Palindrome {
5     public static void main(String[] args) {
6         String str = "nitin";
7         String rev = "";
8
9         for(int i=str.length()-1; i>=0;i--){
10             rev += str.charAt(i);
11         }
12     }
13 }
```

```

12
13     if (str.equals(rev)) {
14         System.out.println(str + " is a palindrome.");
15     }else{
16         System.out.println(str + " is not a palindrome.");
17     }
18 }
19 }

```

Output



```

• (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$ ./ome/yugal/.config/Code/User/workspaceStorage/13eba2f5617b.Palindrome
nitin is a palindrome.
❖ (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$

```

Figure 9: Output of Palindrome Program

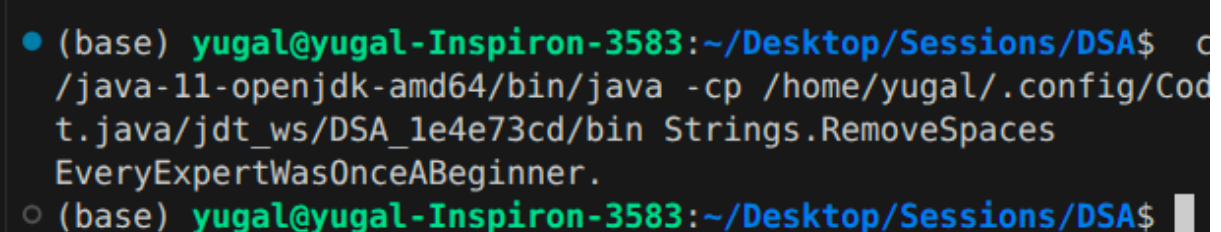
3.3 Remove Spaces from a String

```

1 package Strings;
2 // Remove spaces from string
3 public class RemoveSpaces {
4     public static void main(String[] args) {
5         String str = "Every Expert Was Once A Beginner.";
6         System.out.println(str.replace(" ", ""));
7     }
8 }

```

Output



```

• (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$ ./java-11-openjdk-amd64/bin/java -cp /home/yugal/.config/Code/User/workspaceStorage/13eba2f5617b.DSA_1e4e73cd/bin Strings.RemoveSpaces
EveryExpertWasOnceABeginner.
○ (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$

```

Figure 10: Output of Remove Spaces Program

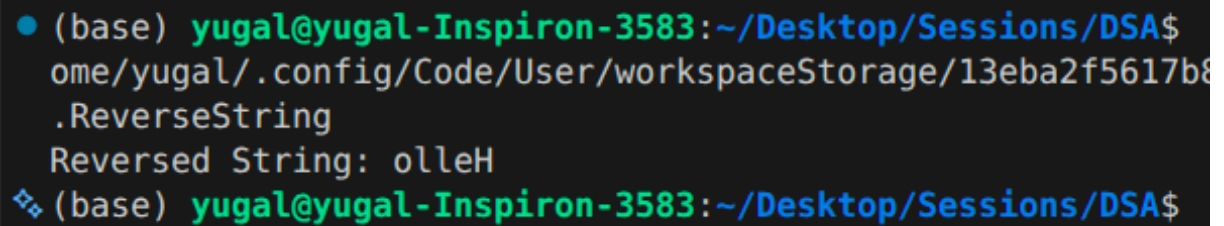
3.4 Reverse a String

```

1 package Strings;
2
3 public class ReverseString {
4
5     public static void main(String[] args) {
6
7         String str = "Hello";
8         String rev = "";
9
10        for(int i = str.length()-1; i>=0; i--){
11            rev = rev + str.charAt(i);
12        }
13        System.out.println("Reversed String: "+ rev);
14
15    }
16 }

```

Output



```

• (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$ java ome/yugal/.config/Code/User/workspaceStorage/13eba2f5617b8 .ReverseString
Reversed String: olleH
❖ (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$

```

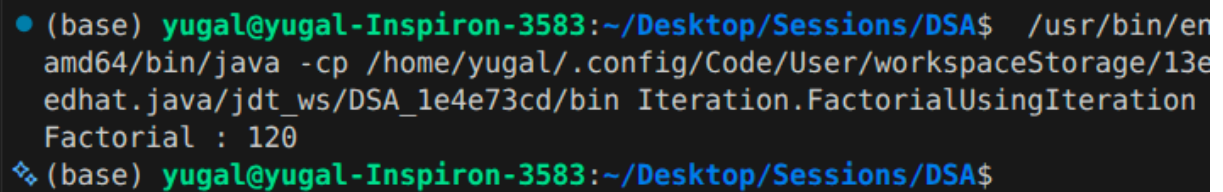
Figure 11: Output of Reverse String Program

Assignment 4: Iteration

4.1 Factorial using Iteration

```
1 package Iteration;
2 // Factorial program using iteration
3 public class FactorialUsingIteration {
4     // Driver code
5     public static void main(String[] args) {
6         int n = 5;
7         int fact = 1;
8         for(int i=1; i<=n; i++){
9             fact *= i;
10        }
11        System.out.println("Factorial : "+fact);
12    }
13 }
```

Output



```
• (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$ /usr/bin/er
amd64/bin/java -cp /home/yugal/.config/Code/User/workspaceStorage/13e
edhat.java/jdt_ws/DSA_1e4e73cd/bin Iteration.FactorialUsingIteration
Factorial : 120
❖ (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$
```

Figure 12: Output of Factorial using Iteration Program

Assignment 5: Searching

5.1 Binary Search

```
1 // Binary Search
2 package Searching;
3 import java.util.Scanner;
4
5 public class BinarySearch {
6
7     //Driver Code
8     public static void main(String[] args) {
9         Scanner sc = new Scanner(System.in);
10        int[] arr = new int[20]; // OK
11        int n = 0, choice, key;
12
13        do{
14            System.out.println("\n ---Binary Search---");
15            System.out.println("1. Insert Elements");
16            System.out.println("2. Display Elements");
17            System.out.println("3. Binary Search");
18            System.out.println("4. Exit");
19
20            System.out.print("Enter your choice: ");
21            choice = sc.nextInt();
22
23            switch (choice) {
24                case 1:
25                    System.out.print("Enter number of elements: ");
26                    n = sc.nextInt();
27                    System.out.println("Enter Elements: ");
28
29                    for(int i=0; i<n; i++){
30                        arr[i] = sc.nextInt();
31                    }
32                    break;
33
34                case 2:
35                    System.out.print("Array Elements: ");
36                    for(int i=0; i<n; i++){
37                        System.out.print(arr[i] + " ");
38                    }
39                    System.out.println();
40                    break;
```



```

41
42         case 3:
43             System.out.print("Enter element to search: ");
44             key = sc.nextInt();
45             int low = 0, high = n-1;
46             boolean found = false;
47             while (low <= high) {
48                 int mid = (low+high) / 2;
49                 if (arr[mid] == key) {
50                     System.out.println("Element found at index:
51                                     " + mid);
52                     found = true;
53                     break;
54                 }
55                 else if (arr[mid] < key) {
56                     low = mid+1;
57                 }
58                 else{
59                     high = mid-1;
60                 }
61             }
62             if (!found)
63                 System.out.println("Element not found");
64             break;
65
66         case 4:
67             System.out.println("Exiting Program");
68             break;
69
70         default:
71             System.out.println("Invalid Choice"); // break not
              compulsory
72     }
73 }
74 while (choice != 4);
75 sc.close();
76 }
77 }

```

Output

```
(base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$ /usr/bin/env /usr/lib/jvm/java-11-openjdk/yugal/.config/Code/User/workspaceStorage/13eba2f5617b89979c97b038c3955178/redhat.java/jdt_
ng.BinarySearch

---Binary Search---
1. Insert Elements
2. Display Elements
3. Binary Search
4. Exit
Enter your choice: 1
Enter number of elements: 2
Enter Elements:
1
2

---Binary Search---
1. Insert Elements
2. Display Elements
3. Binary Search
4. Exit
Enter your choice: 2
Array Elements: 1 2

---Binary Search---
1. Insert Elements
2. Display Elements
3. Binary Search
4. Exit
Enter your choice: 3
```

Figure 13: Output of Binary Search Program

```
(base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$ /usr/bin/
amd64/bin/java -cp /home/yugal/.config/Code/User/workspaceStorage
edhat.java/jdt_ws/DSA_1e4e73cd/bin Searching.BinarySearch

---Binary Search---
1. Insert Elements
2. Display Elements
3. Binary Search
4. Exit
Enter your choice: 2
Array Elements: 1 2

---Binary Search---
1. Insert Elements
2. Display Elements
3. Binary Search
4. Exit
Enter your choice: 3
Enter element to search: 2
Element found at index: 1

---Binary Search---
1. Insert Elements
2. Display Elements
3. Binary Search
4. Exit
Enter your choice: 4
Exiting Program
```

Figure 14: Output of Binary Search Program

5.2 Linear Search

```
1 package Searching;
2
3 import java.util.Scanner;
4
5 public class LinearSearch {
6     public static void main(String[] args) {
7         Scanner sc = new Scanner(System.in);
8         int[] arr = new int[10];
9         int n = 0, choice, key;
10        boolean found;
11    }
```

```

12 do{
13     System.out.println("\n ---Linear Search Menu---");
14     System.out.println("1. Insert Elements");
15     System.out.println("2. Display Elements");
16     System.out.println("3. Linear Search");
17     System.out.println("4. Exit");
18
19     System.out.print("Enter your choice: ");
20     choice = sc.nextInt();
21
22     switch (choice) {
23         case 1:
24             System.out.print("Enter number of elements: ");
25             n = sc.nextInt();
26             System.out.println("Enter Elements: ");
27
28             for(int i=0; i<n; i++){
29                 arr[i] = sc.nextInt();
30             }
31             break;
32
33         case 2:
34             System.out.print("Array Elements: ");
35             for(int i=0; i<n; i++){
36                 System.out.print(arr[i] + " ");
37             }
38             System.out.println();
39             break;
40
41         case 3:
42             System.out.print("Enter element to search: ");
43             key = sc.nextInt();
44             found=false;
45
46             for(int i=0; i<n; i++){
47                 if (arr[i] == key) {
48                     System.out.println("Element found at index:
49                                     " + i);
50                     found = true;
51                     break;
52                 }
53             }
54             if (!found)

```

```
55         System.out.println("Element not found");
56         break;
57
58     case 4:
59         System.out.println("Exiting Program");
60         break;
61
62     default:
63         System.out.println("Invalid Choice");
64         break;
65     }
66 }
67
68 while (choice != 4);
69 sc.close();
70 }
71 }
```

Output

```
• (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$ /usr/bin/python3 /home/yugal/.config/Code/User/workspaceStorage/13eba2f5617b89979ng.LinearSearch

---Linear Search Menu---
1. Insert Elements
2. Display Elements
3. Linear Search
4. Exit
Enter your choice: 1
Enter number of elements: 2
Enter Elements:
1
2

---Linear Search Menu---
1. Insert Elements
2. Display Elements
3. Linear Search
4. Exit
Enter your choice: 2
Array Elements: 1 2

---Linear Search Menu---
1. Insert Elements
2. Display Elements
3. Linear Search
4. Exit
Enter your choice: 3
```

Figure 15: Output of Linear Search Program

```
Enter element to search: 2
Element found at index: 1

---Linear Search Menu---
1. Insert Elements
2. Display Elements
3. Linear Search
4. Exit
Enter your choice: 4
Exiting Program
(base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$
```

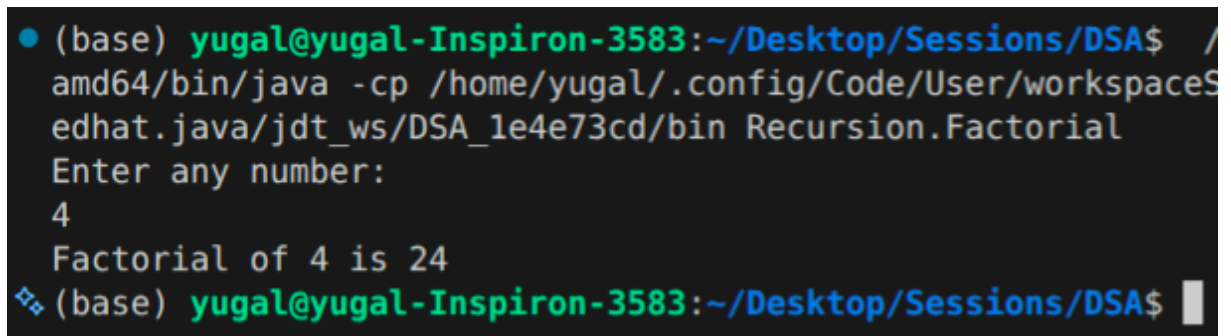
Figure 16: Output of Linear Search Program

Assignment 6: Recursion

6.1 Factorial of a Number using Recursion

```
1 package Recursion;
2
3 import java.util.Scanner;
4
5 // Factorial Program --> eg: 4! = 4*3*2*1 = 24
6 public class Factorial {
7
8     static int factorial(int n){
9         if (n == 0)
10             return 1;
11         return n * factorial(n-1);
12     }
13
14     //Driver Code
15     public static void main(String[] args) {
16
17         System.out.println("Enter any number: ");
18         Scanner sc = new Scanner(System.in);
19         int num = sc.nextInt();
20         System.out.println("Factorial of "+ num + " is "+ factorial(num)
21             );
22         sc.close();
23     }
24 }
```

Output



```
● (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$ java -cp /home/yugal/.config/Code/User/workspaces/edhat.java/jdt_ws/DSA_1e4e73cd/bin Recursion.Factorial
Enter any number:
4
Factorial of 4 is 24
❖ (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$
```

Figure 17: Output of Factorial Program

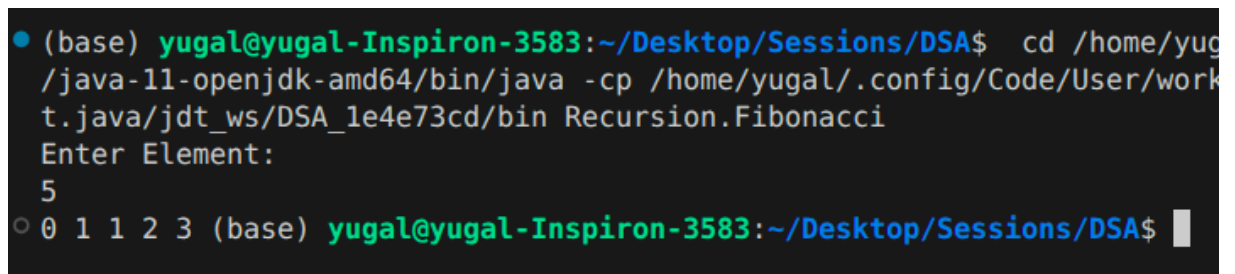
6.2 Fibonacci Series using Recursion


```

1 package Recursion;
2 import java.util.Scanner;
3
4 //Fibonacci Series --> 0,1,0+1=1,1+1=2,2+1=3...
5 public class Fibonacci {
6     static int fibonacci(int n){
7         if (n == 0)
8             return 0;
9         if (n == 1)
10            return 1;
11        return fibonacci(n-1) + fibonacci(n-2);
12    }
13    //Driver Code
14    public static void main(String[] args) {
15
16        Scanner sc = new Scanner(System.in);
17        System.out.println("Enter Element: ");
18
19        int terms = sc.nextInt();
20        for(int i = 0; i<terms; i++){
21            System.out.print(fibonacci(i) + " ");
22            sc.close();
23        }
24    }
25 }

```

Output



```

• (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$ cd /home/yugal/.config/Code/User/workspaces/DSA_1e4e73cd/bin
t.java/jdt_ws/DSA_1e4e73cd/bin Recursion.Fibonacci
Enter Element:
5
○ 0 1 1 2 3 (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$

```

Figure 18: Output of Fibonacci Program

6.3 Palindrome String using Recursion

```

1 package Strings;
2 // Remove spaces from string
3 public class RemoveSpaces {
4     public static void main(String[] args) {

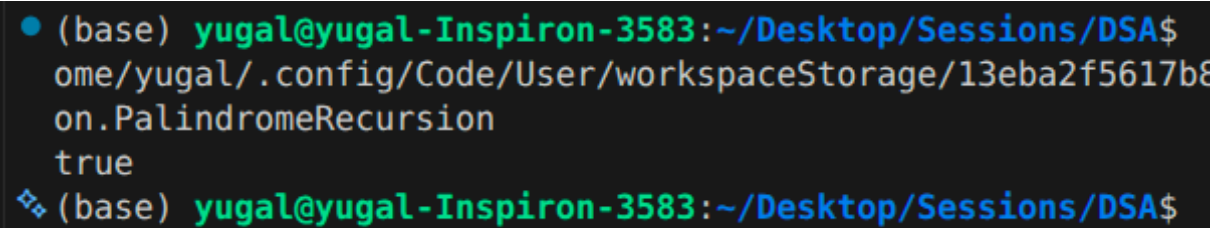
```

```

5      String str = "Every Expert Was Once A Beginner.";
6      System.out.println(str.replace(" ", ""));
7  }
8  }

```

Output



```

• (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$
ome/yugal/.config/Code/User/workspaceStorage/13eba2f5617b8
on.PalindromeRecursion
true
❖ (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$

```

Figure 19: Output of Palindrome Program

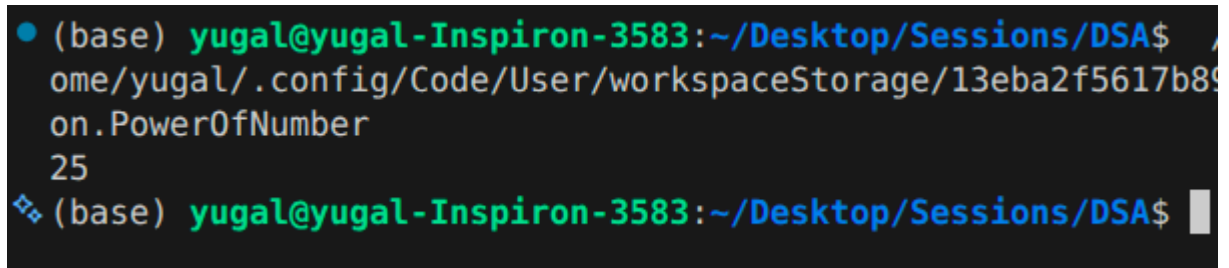
6.4 Power of a number using Recursion

```

1 package Strings;
2
3 public class ReverseString {
4
5     public static void main(String[] args) {
6
7         String str = "Hello";
8         String rev = "";
9
10        for(int i = str.length()-1; i>=0; i--){
11            rev = rev + str.charAt(i);
12        }
13        System.out.println("Reversed String: "+ rev);
14
15    }
16 }

```

Output



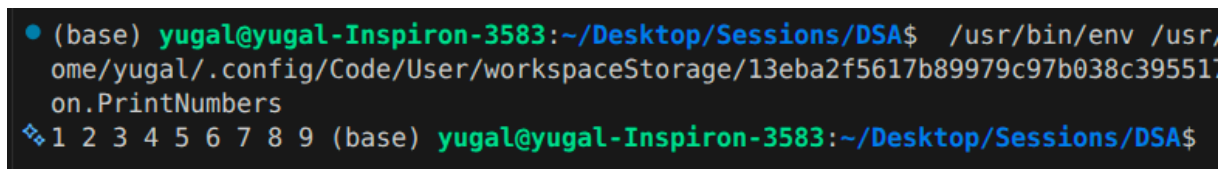
```
(base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$ java -cp /usr/bin/env /usr/bin/java /home/yugal/.config/Code/User/workspaceStorage/13eba2f5617b89979c97b038c395517on.PowerOfNumber
25
(base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$
```

Figure 20: Output of Power of Number Program

6.5 Print numbers using Recursion

```
1 package Strings;
2
3 public class ReverseString {
4
5     public static void main(String[] args) {
6
7         String str = "Hello";
8         String rev = "";
9
10        for(int i = str.length()-1; i>=0; i--){
11            rev = rev + str.charAt(i);
12        }
13        System.out.println("Reversed String: "+ rev);
14
15    }
16 }
```

Output



```
(base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$ java -cp /usr/bin/env /usr/bin/java /usr/bin/java /home/yugal/.config/Code/User/workspaceStorage/13eba2f5617b89979c97b038c395517on.PrintNumbers
1 2 3 4 5 6 7 8 9
(base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$
```

Figure 21: Output of Print Numbers Program

6.6 Recursion Factorial of a Number

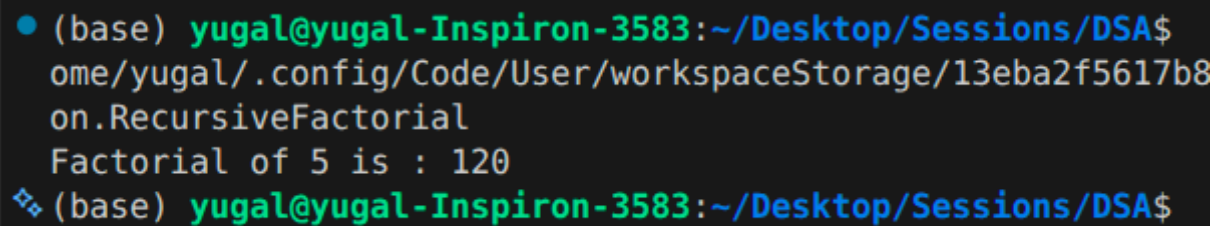
```
1 package Strings;
2
3 public class ReverseString {
```

```

4
5     public static void main(String[] args) {
6
7         String str = "Hello";
8         String rev = "";
9
10        for(int i = str.length()-1; i>=0; i--){
11            rev = rev + str.charAt(i);
12        }
13        System.out.println("Reversed String: "+ rev);
14
15    }
16 }

```

Output



```

• (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$
ome/yugal/.config/Code/User/workspaceStorage/13eba2f5617b8
on.RecursiveFactorial
Factorial of 5 is : 120
❖ (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$

```

Figure 22: Output of Recursion Factorial Program

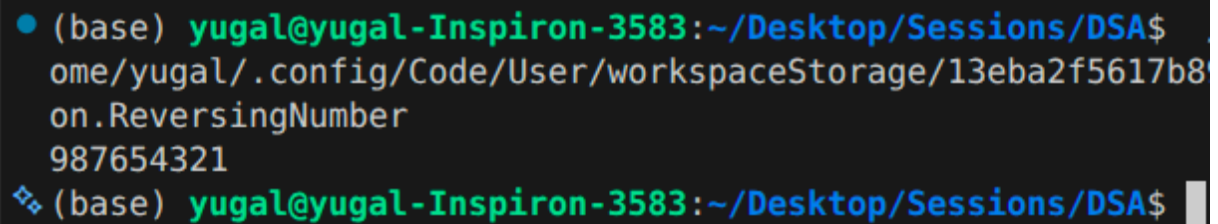
6.7 Reverse Number using Recursion

```

1 package Strings;
2
3 public class ReverseString {
4
5     public static void main(String[] args) {
6
7         String str = "Hello";
8         String rev = "";
9
10        for(int i = str.length()-1; i>=0; i--){
11            rev = rev + str.charAt(i);
12        }
13        System.out.println("Reversed String: "+ rev);
14
15    }
16 }

```

Output

A terminal window with a dark background. The prompt is '(base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA\$'. The user has entered a command that results in the output '987654321'. The prompt is now '(base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA\$' with a cursor at the end.

```
(base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$  
ome/yugal/.config/Code/User/workspaceStorage/13eba2f5617b8  
on.ReversingNumber  
987654321  
(base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$
```

Figure 23: Output of Reverse Number Program

6.8 String Recursion Menu

```
1 package Strings;  
2  
3 public class ReverseString {  
4  
5     public static void main(String[] args) {  
6  
7         String str = "Hello";  
8         String rev = "";  
9  
10        for(int i = str.length()-1; i>=0; i--){  
11            rev = rev + str.charAt(i);  
12        }  
13        System.out.println("Reversed String: "+ rev);  
14  
15    }  
16 }
```

Output

```
• (base) yugal@yugal-Inspiron-3583:~/Desktop/Session/yugal/.config/Code/User/workspaceStorage/1StringRecursionMenu

----STRING RECURSION MENU----
1. Find Length
2. Reverse String
3. Check Palindrome
4. Count Vowels
5. Exit
Enter your choice: 1
Enter a string: yugal
5

----STRING RECURSION MENU----
1. Find Length
2. Reverse String
3. Check Palindrome
4. Count Vowels
5. Exit
Enter your choice: 2
Enter a string: yugal
laguy

----STRING RECURSION MENU----
1. Find Length
2. Reverse String
3. Check Palindrome
4. Count Vowels
```

Figure 24: Output of String Recursion Menu Program

```
5. Exit
Enter your choice: 3
Enter a string: nitin
true

----STRING RECURSION MENU----
1. Find Length
2. Reverse String
3. Check Palindrome
4. Count Vowels
5. Exit
Enter your choice: 4
Enter a string: hello
2

----STRING RECURSION MENU----
1. Find Length
2. Reverse String
3. Check Palindrome
4. Count Vowels
5. Exit
Enter your choice: 5
Program Closed
(base) yugal@yugal-Inspiron-3583:~$
```

Figure 25: Output of String Recursion Menu Program

6.9 Sum of digits using Recursion

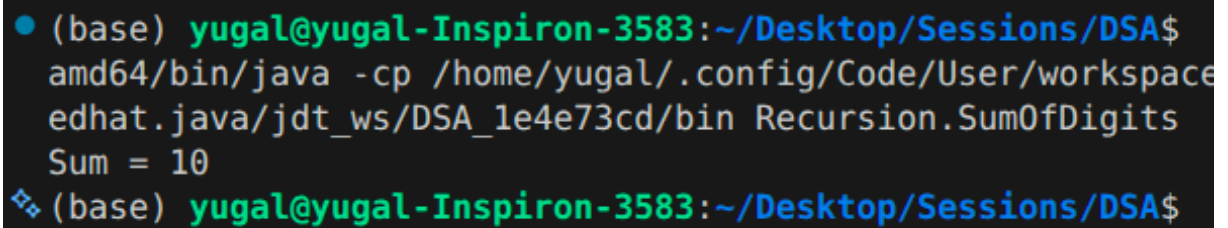
```
1 package Strings;
```

```

2
3 public class ReverseString {
4
5     public static void main(String[] args) {
6
7         String str = "Hello";
8         String rev = "";
9
10        for(int i = str.length()-1; i>=0; i--){
11            rev = rev + str.charAt(i);
12        }
13        System.out.println("Reversed String: " + rev);
14
15    }
16 }

```

Output



```

• (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$
  amd64/bin/java -cp /home/yugal/.config/Code/User/workspace
  edhat.java/jdt_ws/DSA_1e4e73cd/bin Recursion.SumOfDigits
  Sum = 10
❖ (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$

```

Figure 26: Output of Sum of Digits Program

Assignment 7: Linked List

7.1 Singly-Linked-List

```
1 public class SinglyLinkedList {
2     // Node class
3     class Node{
4         int data;
5         Node next;
6         Node(int data){
7             this.data = data;
8             this.next = null;
9         }
10    }
11
12    Node head = null;
13    // Insert at end
14    public void insertEnd(int data){
15        Node newNode = new Node(data);
16        if(head == null){
17            head = newNode;
18            return;
19        }
20
21        Node temp = head;
22        while(temp.next != null){
23            temp = temp.next;
24        }
25        temp.next = newNode;
26    }
27
28    // Insert at beginning
29    public void insertBeginning(int data){
30        Node newNode = new Node(data);
31        newNode.next = head;
32        head = newNode;
33    }
34
35    // Delete by value
36    public void delete(int key){
37        if (head == null)
38            return;
39        if (head.data == key) {
40            head = head.next;
```

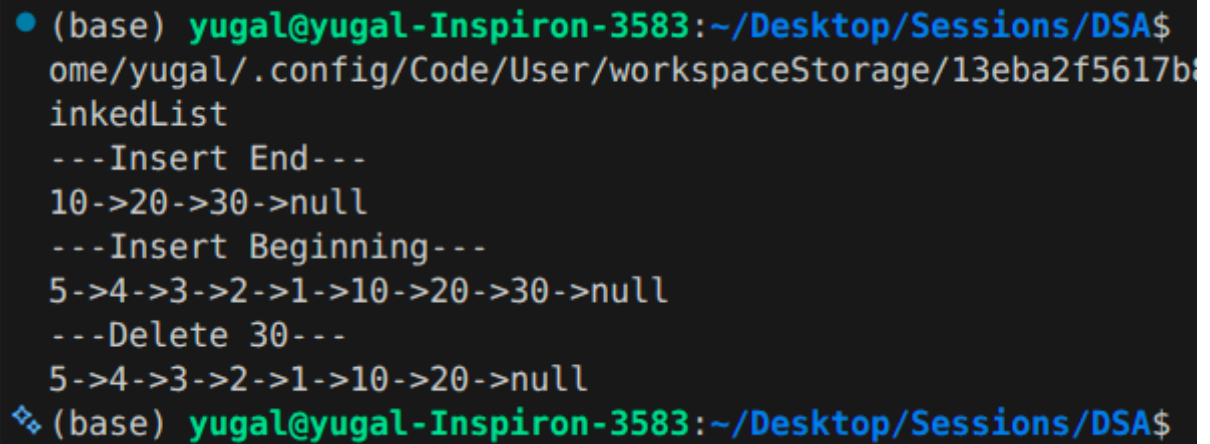
```

41         return;
42     }
43
44     Node temp = head;
45     while (temp.next != null && temp.next.data != key) {
46         temp = temp.next;
47     }
48     if(temp.next != null){
49         temp.next = temp.next.next;
50     }
51 }
52
53 // Traverse
54 public void display(){
55     Node temp = head;
56     while(temp != null){
57         System.out.print(temp.data + "->");
58         temp = temp.next;
59     }
60
61     System.out.println("null");
62 }
63
64 // Driver code
65 public static void main(String[] args) {
66     SinglyLinkedList list = new SinglyLinkedList();
67     list.insertEnd(10);
68     list.insertEnd(20);
69     list.insertEnd(30);
70     System.out.println("---Insert End---");
71     list.display();
72     list.insertBeginning(1);
73     list.insertBeginning(2);
74     list.insertBeginning(3);
75     list.insertBeginning(4);
76     list.insertBeginning(5);
77     System.out.println("---Insert Beginning---");
78     list.display();
79
80     list.delete(30);
81     System.out.println("---Delete 30---");
82     list.display();
83 }
84

```

```
85  
86 }
```

Output



```
• (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$  
ome/yugal/.config/Code/User/workspaceStorage/13eba2f5617b:  
inkedList  
---Insert End---  
10->20->30->null  
---Insert Beginning---  
5->4->3->2->1->10->20->30->null  
---Delete 30---  
5->4->3->2->1->10->20->null  
❖ (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$
```

Figure 27: Singly Linked List Output

7.2 Doubly-Linked-List

```
1 // Doubly Linked List Program  
2 public class DoublyLinkedList {  
3     // Node class  
4     class Node{  
5         int data;  
6         Node prev; // Previous  
7         Node next; //Next Pointer  
8         Node(int data){  
9             this.data = data;  
10            this.prev = null;  
11            this.next = null;  
12        }  
13    }  
14    Node head = null;  
15  
16    // Insert at beginning  
17    public void insertAtBeginning(int data){  
18        Node newNode = new Node(data);  
19        if(head == null){  
20            head = newNode;  
21            return;  
22        }  
23    }  
24 }
```

```

23         newNode.next = head;
24         head.prev = newNode;
25         head = newNode;
26     }
27
28     // Insert at end
29     public void insertAtEnd(int data){
30         Node newNode = new Node(data);
31         if(head == null){
32             head = newNode;
33             return;
34         }
35         Node temp = head;
36         while (temp.next != null) {
37             temp = temp.next;
38         }
39         temp.next = newNode;
40         newNode.prev = temp;
41     }
42
43     // Insert at Position (1- Based Index)
44     public void insertAtPosition(int data, int position){
45         if (position <= 0) {
46             System.out.println("Invalid Position");
47             return;
48         }
49         if (position == 1) {
50             insertAtBeginning(data);
51             return;
52         }
53         Node newNode = new Node(data);
54         Node temp = head;
55
56         for(int i=1; temp != null && i<position-1; i++){
57             temp = temp.next;
58         }
59         if (temp == null) {
60             System.out.println("Position out of range");
61             return;
62         }
63         newNode.next = temp.next;
64         if (temp.next != null) {
65             temp.next.prev = newNode;
66         }

```

```

67         temp.next = newNode;
68         newNode.prev = temp;
69     }
70
71     // Delete from Beginning
72     public void deleteFromBeginning(){
73         if (head == null) {
74             System.out.println("List is Empty");
75             return;
76         }
77         head = head.next;
78         if (head != null) {
79             head.prev = null;
80         }
81     }
82
83     // Delete from End
84     public void deleteFromEnd(){
85         if (head == null) {
86             System.out.println("List is Empty");
87             return;
88         }
89         if (head.next == null) {
90             head = null;
91             return;
92         }
93         Node temp = head;
94         while (temp.next != null) {
95             temp = temp.next;
96         }
97         temp.prev.next = null;
98     }
99
100    // Delete from Position
101    public void deleteFromPosition(int position){
102        if (head == null || position <= 0) {
103            System.out.println("Invalid Operation");
104            return;
105        }
106        if(position == 1){
107            deleteFromBeginning();
108            return;
109        }
110        Node temp = head;

```

```

111         for(int i =1; temp != null && i < position; i++){
112             temp = temp.next;
113         }
114         if (temp == null) {
115             System.out.println("Position out of Range.");
116             return;
117         }
118         if (temp.next != null) {
119             temp.next.prev = temp.prev;
120         }
121         if (temp.prev != null) {
122             temp.prev.next = temp.next;
123         }
124     }
125
126     // Search
127     public void search(int key){
128         Node temp = head;
129         int position = 1;
130         while (temp != null) {
131             if (temp.data == key) {
132                 System.out.println("Element found at position: "+
133                     position);
134                 return;
135             }
136             temp = temp.next;
137             position++;
138         }
139         System.out.println("Element Not Found!");
140     }
141
142     // Display forward
143     public void displayForward(){
144         Node temp = head;
145         System.out.print("Forward: ");
146         while (temp != null) {
147             System.out.print(temp.data + " ");
148             temp = temp.next;
149         }
150         System.out.println();
151     }
152     // Display Backward
153     public void displayBackward(){
154         if (head == null)

```

```

154         return;
155     Node temp = head;
156     while (temp.next != null) {
157         temp = temp.next;
158     }
159     System.out.print("Backward: ");
160     while (temp != null) {
161         System.out.print(temp.data + " ");
162         temp = temp.prev;
163     }
164     System.out.println();
165 }
166
167 // Driver code
168 public static void main(String[] args) {
169     DoublyLinkedList dll = new DoublyLinkedList();
170     dll.insertAtBeginning(10);
171     dll.insertAtBeginning(5);
172     dll.insertAtBeginning(50);
173     dll.insertAtBeginning(100);
174     dll.insertAtEnd(20);
175     dll.insertAtEnd(1000);
176     dll.insertAtEnd(2000);
177     dll.insertAtEnd(3000);
178     dll.insertAtEnd(25);
179     dll.insertAtPosition(15, 3);
180     dll.insertAtPosition(500, 1);
181     dll.displayForward();
182     dll.displayBackward();
183     dll.search(15);
184     dll.deleteFromBeginning();
185     dll.deleteFromEnd();
186     dll.deleteFromPosition(2);
187     dll.displayForward();
188     dll.displayBackward();
189
190 }
191 }

```

Output

```
• (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$  
ome/yugal/.config/Code/User/workspaceStorage/13eba2f5617b8  
inkedList  
Forward: 500 100 50 15 5 10 20 1000 2000 3000 25  
Backward: 25 3000 2000 1000 20 10 5 15 50 100 500  
Element found at position: 4  
Forward: 100 15 5 10 20 1000 2000 3000  
Backward: 3000 2000 1000 20 10 5 15 100  
❖ (base) yugal@yugal-Inspiron-3583:~/Desktop/Sessions/DSA$
```

Figure 28: Output of Doubly Linked List Program