❖ ASSIGNMENT NUMBER 3:

		CO	BL
	Objective: • Understand and implement Divide and Conquer strategies. • Apply Greedy Method for optimization problems. • Analyse time complexity and behaviour of the algorithms through practical coding.		
Q.1	**Binary Search Implementation:** • **Task:** Write a program to perform binary search on a sorted array. • **Requirements:** • Implement both recursive and iterative versions. • Display the number of comparisons made. • **Input:** Sorted array of integers and a target element. • **Output:** Index of the element (or appropriate message if not found).	CO3	BL3
Q.2	**Quick Sort Implementation** • **Task:** Implement the Quick Sort algorithm. • **Requirements:** • Use a pivot selection strategy (first element, last element, or median). • Track the number of comparisons and swaps. • **Input:** Unsorted array of integers. • **Output:** Sorted array.	CO3	BL3
Q.3	**Strassen's Matrix Multiplication** • **Task:** Implement Strassen's algorithm for matrix multiplication. • **Requirements:** • Handle matrices of size 2^n × 2^n (padding if necessary). • Compare execution time with conventional matrix multiplication. • **Input:** Two matrices. • **Output:** Product matrix.	CO3	BL3
Q.4	**Greedy Method Algorithms** Minimum Cost Spanning Tree (MST) • **Task:** Implement Prim's and Kruskal's algorithms to find MST. • **Requirements:** • Print the edges included in the MST and total cost. • **Input:** A connected, weighted undirected graph (using adjacency matrix or adjacency list). **Output:** MST and total minimum cost.	CO3	BL3

By Assistant Professor: Megha Rathore

Q.5	**Knapsack Problem (Fractional)** • **Task:** Solve the Fractional Knapsack Problem using a greedy approach. • **Requirements:** • Items should be sorted based on value/weight ratio. • Allow taking fractions of an item. • Input: Arrays of weights, values, and the capacity of the knapsack. • Output: Maximum value that can be put in the knapsack.	CO3	BL3

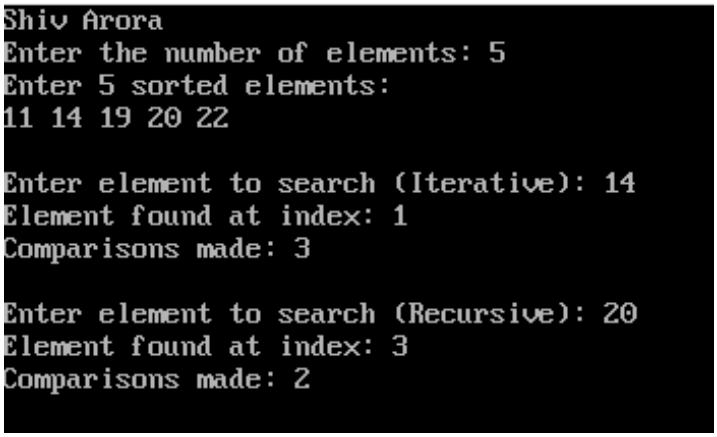
Q1) Binary Search Implementation:

```
#include <iostream.h>
#include <conio.h>
class BinarySearch {
   int arr[100], size, comparisons;
public:
   BinarySearch() {
      comparisons = 0;
      size = 0;
   }
   void input() {
      cout << "Enter the number of elements: ";
      cin >> size;
      cout << "Enter " << size << " sorted elements:\n";
      for (int i = 0; i < size; i++) {
         cin >> arr[i];
      }
   }
   void iterativeSearch() {
      int key;
      comparisons = 0;
      cout << "\nEnter element to search (Iterative): ";
      cin >> key;
      int low = 0, high = size - 1, mid, index = -1;
      while (low <= high) {
         comparisons++;
         mid = (low + high) / 2;
         if (arr[mid] == key) {
            index = mid;
            break;
         } else if (arr[mid] < key) {
            low = mid + 1;
```

```
        } else {
            high = mid - 1;
        }
    }
    if (index == -1)
        cout << "Element not found.\n";
    else
        cout << "Element found at index: " << index << "\n";
    cout << "Comparisons made: " << comparisons << "\n";
}
void recursiveSearchWrapper() {
    int key;
    comparisons = 0;
    cout << "\nEnter element to search (Recursive): ";
    cin >> key;
    int index = recursiveSearch(key, 0, size - 1);
    if (index == -1)
        cout << "Element not found.\n";
    else
        cout << "Element found at index: " << index << "\n";
    cout << "Comparisons made: " << comparisons << "\n";
}
int recursiveSearch(int key, int low, int high) {
    if (low > high)
        return -1;
    comparisons++;
    int mid = (low + high) / 2;
    if (arr[mid] == key)
        return mid;
    else if (arr[mid] < key)
        return recursiveSearch(key, mid + 1, high);
    else
```

```
            return recursiveSearch(key, low, mid - 1);
        }
        void run() {
            input();
            iterativeSearch();
            recursiveSearchWrapper();
        }
    };
    void main() {
        clrscr();
        cout << "Shiv Arora"<< endl;
        BinarySearch bs;
        bs.run();
        getch();
    }
```

OUTPUT:



Q2) Quick Sort Implementation:

```
    #include <iostream.h>
    #include <conio.h>
    class QuickSort {
        int arr[100], n;
        int cmpFirst, swpFirst;
        int cmpMid, swpMid;
        int cmpLast, swpLast;
```

```
public:
    void input() {
        cout << "Enter number of elements: ";
        cin >> n;

        cout << "Enter " << n << " elements:\n";
        for (int i = 0; i < n; i++) {
            cin >> arr[i];
        }
    }
    void displayArray(int a[]) {
        for (int i = 0; i < n; i++) {
            cout << a[i] << " ";
        }
        cout << "\n";
    }
    void copyArray(int src[], int dest[]) {
        for (int i = 0; i < n; i++) {
            dest[i] = src[i];
        }
    }
    void quickSortFirst(int a[], int low, int high) {
        if (low < high) {
            int p = partitionFirst(a, low, high);
            quickSortFirst(a, low, p - 1);
            quickSortFirst(a, p + 1, high);
        }
    }
    int partitionFirst(int a[], int low, int high) {
        int pivot = a[low];
        int i = low + 1;
        int j = high;
```

```
    while (i <= j) {
        while (i <= high && a[i] <= pivot) {
            cmpFirst++;
            i++;
        }
        while (j >= low && a[j] > pivot) {
            cmpFirst++;
            j--;
        }
        if (i < j) {
            int temp = a[i];
            a[i] = a[j];
            a[j] = temp;
            swpFirst++;
        }
    }
    int temp = a[low];
    a[low] = a[j];
    a[j] = temp;
    swpFirst++;
    return j;
}
void quickSortMiddle(int a[], int low, int high) {
    if (low < high) {
        int p = partitionMiddle(a, low, high);
        quickSortMiddle(a, low, p - 1);
        quickSortMiddle(a, p + 1, high);
    }
}
int partitionMiddle(int a[], int low, int high) {
    int mid = (low + high) / 2;
    int temp = a[low];
```

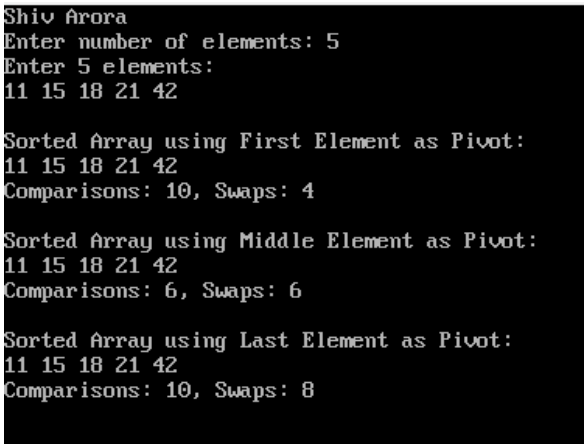
```
    a[low] = a[mid];
    a[mid] = temp;
    swpMid++;
    int pivot = a[low];
    int i = low + 1;
    int j = high;
    while (i <= j) {
        while (i <= high && a[i] <= pivot) {
            cmpMid++;
            i++;
        }
        while (j >= low && a[j] > pivot) {
            cmpMid++;
            j--;
        }
        if (i < j) {
            temp = a[i];
            a[i] = a[j];
            a[j] = temp;
            swpMid++;
        }
    }
    temp = a[low];
    a[low] = a[j];
    a[j] = temp;
    swpMid++;
    return j;
}
void quickSortLast(int a[], int low, int high) {
    if (low < high) {
        int p = partitionLast(a, low, high);
        quickSortLast(a, low, p - 1);
```

```
            quickSortLast(a, p + 1, high);
        }
    }
    int partitionLast(int a[], int low, int high) {
        int temp = a[low];
        a[low] = a[high];
        a[high] = temp;
        swpLast++;
        int pivot = a[low];
        int i = low + 1;
        int j = high;
        while (i <= j) {
            while (i <= high && a[i] <= pivot) {
                cmpLast++;
                i++;
            }
            while (j >= low && a[j] > pivot) {
                cmpLast++;
                j--;
            }
            if (i < j) {
                temp = a[i];
                a[i] = a[j];
                a[j] = temp;
                swpLast++;
            }
        }
        temp = a[low];
        a[low] = a[j];
        a[j] = temp;
        swpLast++;
        return j;
```

```
    }
    void sortAndDisplayAll() {
        int tempArr[100];
        // First Element Pivot
        cmpFirst = swpFirst = 0;
        copyArray(arr, tempArr);
        quickSortFirst(tempArr, 0, n - 1);
        cout << "\nSorted Array using First Element as Pivot:\n";
        displayArray(tempArr);
        cout << "Comparisons: " << cmpFirst << ", Swaps: " << swpFirst << "\n";
        // Middle Element Pivot
        cmpMid = swpMid = 0;
        copyArray(arr, tempArr);
        quickSortMiddle(tempArr, 0, n - 1);
        cout << "\nSorted Array using Middle Element as Pivot:\n";
        displayArray(tempArr);
        cout << "Comparisons: " << cmpMid << ", Swaps: " << swpMid << "\n";
        // Last Element Pivot
        cmpLast = swpLast = 0;
        copyArray(arr, tempArr);
        quickSortLast(tempArr, 0, n - 1);
        cout << "\nSorted Array using Last Element as Pivot:\n";
        displayArray(tempArr);
        cout << "Comparisons: " << cmpLast << ", Swaps: " << swpLast << "\n";
    }
};
void main() {
    clrscr();
    cout << "Shiv Arora"<< endl;
    QuickSort qs;
    qs.input();
    qs.sortAndDisplayAll();
```

```
    getch();
}
```

OUTPUT:



Q3) Strassen's matrix multiplication:

```
#include <iostream.h>
#include <conio.h>
#define MAX 32  // Maximum matrix size
class Strassen {
    int A[MAX][MAX], B[MAX][MAX], C[MAX][MAX];
    int n;
public:
    void run() {
        cout << "Enter matrix size (2^n, max " << MAX << "): ";
        cin >> n;
        if (n != 1 && n != 2 && n != 4 && n != 8) {
            cout << "Only 2^n sizes (1, 2, 4, 8, 16, 32) allowed.\n";
            return;
        }
        cout << "Enter elements of Matrix A:\n";
        for (int i = 0; i < n; i++)
            for (int j = 0; j < n; j++)
                cin >> A[i][j];
        cout << "Enter elements of Matrix B:\n";
    for (int s = 0; s < n; s++)
```

```
        for (int t = 0; t < n; t++)
        cin >> B[s][t];
        strassenMultiply(A, B, C, n);
        cout << "\nResultant Matrix C = A * B:\n";
        display(C, n);
        getch();
    }
    void display(int M[MAX][MAX], int size) {
        for (int i = 0; i < size; i++) {
            for (int j = 0; j < size; j++)
                cout << M[i][j] << " ";
            cout << "\n";
        }
    }
    void add(int A[MAX][MAX], int B[MAX][MAX], int result[MAX][MAX], int size) {
        for (int i = 0; i < size; i++)
            for (int j = 0; j < size; j++)
                result[i][j] = A[i][j] + B[i][j];
    }
    void subtract(int A[MAX][MAX], int B[MAX][MAX], int result[MAX][MAX], int size) {
        for (int i = 0; i < size; i++)
            for (int j = 0; j < size; j++)
                result[i][j] = A[i][j] - B[i][j];
    }
    void strassenMultiply(int A[MAX][MAX], int B[MAX][MAX], int C[MAX][MAX], int
size) {
        if (size == 1) {
            C[0][0] = A[0][0] * B[0][0];
            return;
        }
        int newSize = size / 2;
        int A11[MAX][MAX], A12[MAX][MAX], A21[MAX][MAX], A22[MAX][MAX];
        int B11[MAX][MAX], B12[MAX][MAX], B21[MAX][MAX], B22[MAX][MAX];
```

```
int C11[MAX][MAX], C12[MAX][MAX], C21[MAX][MAX], C22[MAX][MAX];
int M1[MAX][MAX], M2[MAX][MAX], M3[MAX][MAX], M4[MAX][MAX];
int M5[MAX][MAX], M6[MAX][MAX], M7[MAX][MAX];
int T1[MAX][MAX], T2[MAX][MAX];
for (int i = 0; i < newSize; i++) {
   for (int j = 0; j < newSize; j++) {
      A11[i][j] = A[i][j];
      A12[i][j] = A[i][j + newSize];
      A21[i][j] = A[i + newSize][j];
      A22[i][j] = A[i + newSize][j + newSize];
      B11[i][j] = B[i][j];
      B12[i][j] = B[i][j + newSize];
      B21[i][j] = B[i + newSize][j];
      B22[i][j] = B[i + newSize][j + newSize];
   }
}
add(A11, A22, T1, newSize);
add(B11, B22, T2, newSize);
strassenMultiply(T1, T2, M1, newSize);
add(A21, A22, T1, newSize);
strassenMultiply(T1, B11, M2, newSize);
subtract(B12, B22, T1, newSize);
strassenMultiply(A11, T1, M3, newSize);
subtract(B21, B11, T1, newSize);
strassenMultiply(A22, T1, M4, newSize);
add(A11, A12, T1, newSize);
strassenMultiply(T1, B22, M5, newSize);
subtract(A21, A11, T1, newSize);
add(B11, B12, T2, newSize);
strassenMultiply(T1, T2, M6, newSize);
subtract(A12, A22, T1, newSize);
add(B21, B22, T2, newSize);
```

```
            strassenMultiply(T1, T2, M7, newSize);
            add(M1, M4, T1, newSize);
            subtract(T1, M5, T2, newSize);
            add(T2, M7, C11, newSize);
            add(M3, M5, C12, newSize);
            add(M2, M4, C21, newSize);
            subtract(M1, M2, T1, newSize);
            add(T1, M3, T2, newSize);
            add(T2, M6, C22, newSize);
         for (int q = 0; q < newSize; q++) {
            for (int j = 0; j < newSize; j++) {
            C[q][j] = C11[q][j];
            C[q][j + newSize] = C12[q][j];
            C[q + newSize][j] = C21[q][j];
            C[q + newSize][j + newSize] = C22[q][j];
            }
            }
         }
      };
      void main() {
         clrscr();
         cout << "Shiv Arora"<< endl;
         Strassen s;
         s.run();
         getch();
      }
```

OUTPUT:

```
Shiv Arora
Enter matrix size (2^n, max 32): 2
Enter elements of Matrix A:
1 5 4 9
Enter elements of Matrix B:
5 4 3 7

Resultant Matrix C = A * B:
20 39
47 79
```

Q4) Greedy Method Algorithm:

```
#include <iostream.h>
#include <conio.h>
#define MAX 20
#define INF 9999
class MST {
private:
   int V, E;
   int adj[MAX][MAX];     // For Prim
   int edges[MAX][3];     // For Kruskal: u, v, weight
public:
   MST() {
      for (int i = 0; i < MAX; i++)
         for (int j = 0; j < MAX; j++)
            adj[i][j] = INF;
   }
   void readGraph() {
      cout << "Enter number of vertices and edges: ";
      cin >> V >> E;
      cout << "Enter edges (u v weight):\n";
      for (int i = 0; i < E; i++) {
         int u, v, w;
         cin >> u >> v >> w;
         edges[i][0] = u;
         edges[i][1] = v;
         edges[i][2] = w;
```

```
            adj[u][v] = w;
            adj[v][u] = w;
        }
    }
    void kruskalMST() {
        int parent[MAX];
        int i, j, u, v;
        int count = 0, total = 0;
        for (i = 0; i < V; i++)
            parent[i] = i;
        // Simple Bubble Sort by weight
        for (i = 0; i < E - 1; i++) {
            for (j = 0; j < E - i - 1; j++) {
                if (edges[j][2] > edges[j + 1][2]) {
                    int temp0 = edges[j][0];
                    int temp1 = edges[j][1];
                    int temp2 = edges[j][2];
                    edges[j][0] = edges[j + 1][0];
                    edges[j][1] = edges[j + 1][1];
                    edges[j][2] = edges[j + 1][2];
                    edges[j + 1][0] = temp0;
                    edges[j + 1][1] = temp1;
                    edges[j + 1][2] = temp2;
                }
            }
        }
        cout << "\nKruskal's MST:\n";
        for (i = 0; i < E && count < V - 1; i++) {
            u = find(parent, edges[i][0]);
            v = find(parent, edges[i][1]);
            if (u != v) {
                cout << edges[i][0] << " - " << edges[i][1] << " : " << edges[i][2] << "\n";
```

```
            total += edges[i][2];
            unionSet(parent, u, v);
            count++;
        }
    }
    cout << "Total weight: " << total << "\n";
}
void primMST() {
    int visited[MAX] = {0};
    int min, u = 0, v = 0, total = 0;
    int count = 0;
    visited[0] = 1;
    cout << "\nPrim's MST:\n";
    while (count < V - 1) {
        min = INF;
        for (int i = 0; i < V; i++) {
            if (visited[i]) {
                for (int j = 0; j < V; j++) {
                    if (!visited[j] && adj[i][j] < min) {
                        min = adj[i][j];
                        u = i;
                        v = j;
                    }
                }
            }
        }
        cout << u << " - " << v << " : " << adj[u][v] << "\n";
        visited[v] = 1;
        total += adj[u][v];
        count++;
    }
    cout << "Total weight: " << total << "\n";
```

```
    }
    int find(int parent[], int i) {
        while (parent[i] != i)
            i = parent[i];
        return i;
    }
    void unionSet(int parent[], int u, int v) {
        parent[u] = v;
    }
};
void main() {
    clrscr();
    cout << "Shiv Arora"<< endl;
    MST mst;
    mst.readGraph();
    int choice;
    cout << "\nChoose MST Algorithm:\n1. Kruskal\n2. Prim\nEnter choice: ";
    cin >> choice;
    if (choice == 1)
        mst.kruskalMST();
    else if (choice == 2)
        mst.primMST();
    else
        cout << "Invalid choice";
    getch();
}
```

OUTPUT:

```
Shiv Arora
Enter number of vertices and edges:  4 4
Enter edges (u v weight):
2 0 5
0 1 6
0 3 2
1 3 1

Choose MST Algorithm:
1. Kruskal
2. Prim
Enter choice: 1

Kruskal's MST:
1 - 3 : 1
0 - 3 : 2
2 - 0 : 5
Total weight: 8
```

Q5) Knapsack Problem:

```
#include <iostream.h>
#include <conio.h>
#define MAX 100
class Knapsack {
   float weights[MAX], values[MAX], ratio[MAX];
   int n;
   float capacity;
public:
   void run() {
      cout << "Enter number of items (max " << MAX << "): ";
      cin >> n;
      cout << "Enter weights of items:\n";
      for (int i = 0; i < n; i++)
         cin >> weights[i];
   cout << "Enter values of items:\n";
   for (int j = 0; j < n; j++)
      cin >> values[j];
   cout << "Enter capacity of knapsack: ";
   cin >> capacity;
   for (int k = 0; k < n; k++)
```

```
    ratio[k] = values[k] / weights[k];
    sortItems();
    float maxValue = fillKnapsack();
    cout << "\nMaximum value in knapsack = " << maxValue;
}
void sortItems() {
    for (int i = 0; i < n - 1; i++) {
        for (int j = i + 1; j < n; j++) {
            if (ratio[i] < ratio[j]) {
                float temp;
                temp = ratio[i];
                ratio[i] = ratio[j];
                ratio[j] = temp;
                temp = weights[i];
                weights[i] = weights[j];
                weights[j] = temp;
                temp = values[i];
                values[i] = values[j];
                values[j] = temp;
            }
        }
    }
}
float fillKnapsack() {
    float totalValue = 0.0;
    float currWeight = 0.0;
    for (int i = 0; i < n; i++) {
        if (currWeight + weights[i] <= capacity) {
            currWeight += weights[i];
            totalValue += values[i];
        } else {
            float remain = capacity - currWeight;
```

```
                totalValue += ratio[i] * remain;
                break;
            }
        }
        return totalValue;
    }
};
void main() {
    clrscr();
    cout << "Shiv Arora"<< endl;
    Knapsack k;
    k.run();
    getch();
}
```

OUTPUT:

```
Shiv Arora
Enter number of items (max 100): 5
Enter weights of items:
 5 4 3 7 9
Enter values of items:
7 2 6 4 8
Enter capacity of knapsack: 20

Maximum value in knapsack = 22.714285_
```