BHARATI VIDYAPEETH'S

INSTITUTE OF COMPUTER APPLICATIONS & MANAGEMENT

(Affiliated to Guru Gobind Singh Indraprastha University,

Approved by AICTE, New Delhi)

Design and Analysis of Algorithms (MCA- 261) Practical File

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MCA 3rd Sem, Sec. 1

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P1 Write a program to implement bubble sort

```
#include <iostream>
using namespace std;

void bubbleSort(int arr[], int n) {
  for (int i = 0; i < n-1; i++) {
    // Last i elements are already sorted
    for (int j = 0; j < n-i-1; j++) {
      // Swap if the element is greater than the next
      if (arr[j] > arr[j+1]) {
        int temp = arr[j];
        arr[j] = arr[j+1];
        arr[j+1] = temp;
      }
    }
  }
}

void printArray(int arr[], int n) {
  for (int i = 0; i < n; i++)
    cout << arr[i] << " ";
  cout << endl;
}

int main() {
  int arr[] = {64, 34, 25, 12, 22, 11, 90};
```

```
    int n = sizeof(arr)/sizeof(arr[0]);
    cout << "Unsorted array: ";
    printArray(arr, n);

    bubbleSort(arr, n);

    cout << "Sorted array: ";
    printArray(arr, n);
    return 0;
}
```

Output   Clear

```
Unsorted array: 64 34 25 12 22 11 90
Sorted array: 11 12 22 25 34 64 90


=== Code Execution Successful ===
```

P2 Write a program to implement quick sort.

```
#include <iostream>
using namespace std;

int partition(int arr[], int low, int high) {
  int pivot = arr[high];
  int i = (low - 1);

  for (int j = low; j <= high - 1; j++) {
    if (arr[j] < pivot) {
      i++;
      swap(arr[i], arr[j]);
    }
  }
  swap(arr[i + 1], arr[high]);
  return (i + 1);
}

void quickSort(int arr[], int low, int high) {
  if (low < high) {
    int pi = partition(arr, low, high);
    quickSort(arr, low, pi - 1);
    quickSort(arr, pi + 1, high);
  }
}
```

```
void printArray(int arr[], int n) {
    for (int i = 0; i < n; i++)
        cout << arr[i] << " ";
    cout << endl;
}

int main() {
    int arr[] = {10, 80, 30, 90, 40, 50, 70};
    int n = sizeof(arr)/sizeof(arr[0]);
    quickSort(arr, 0, n-1);
    cout << "Sorted array: ";
    printArray(arr, n);
    return 0;
}
```

Output Clear

```
Unsorted array: 10 80 30 90 40 50 70
Sorted array: 10 30 40 50 70 80 90


=== Code Execution Successful ===
```

P3 Write a program to implement merge sort.

```
#include <iostream>
using namespace std;

void merge(int arr[], int l, int m, int r) {
   int n1 = m - l + 1;
   int n2 = r - m;
   int L[n1], R[n2];

   for (int i = 0; i < n1; i++)
      L[i] = arr[l + i];
   for (int i = 0; i < n2; i++)
      R[i] = arr[m + 1 + i];

   int i = 0, j = 0, k = l;
   while (i < n1 && j < n2) {
      if (L[i] <= R[j]) {
         arr[k] = L[i];
         i++;
      } else {
         arr[k] = R[j];
         j++;
      }
      k++;
   }
```

```
  while (i < n1) {
    arr[k] = L[i];
    i++;
    k++;
  }

  while (j < n2) {
    arr[k] = R[j];
    j++;
    k++;
  }
}

void mergeSort(int arr[], int l, int r) {
  if (l < r) {
    int m = l + (r - l) / 2;
    mergeSort(arr, l, m);
    mergeSort(arr, m + 1, r);
    merge(arr, l, m, r);
  }
}

void printArray(int arr[], int n) {
  for (int i = 0; i < n; i++)
    cout << arr[i] << " ";
  cout << endl;
```

```
}

int main() {
  int arr[] = {12, 11, 13, 5, 6, 7};
  int n = sizeof(arr) / sizeof(arr[0]);
  mergeSort(arr, 0, n - 1);
  cout << "Sorted array: ";
  printArray(arr, n);
  return 0;
}
```

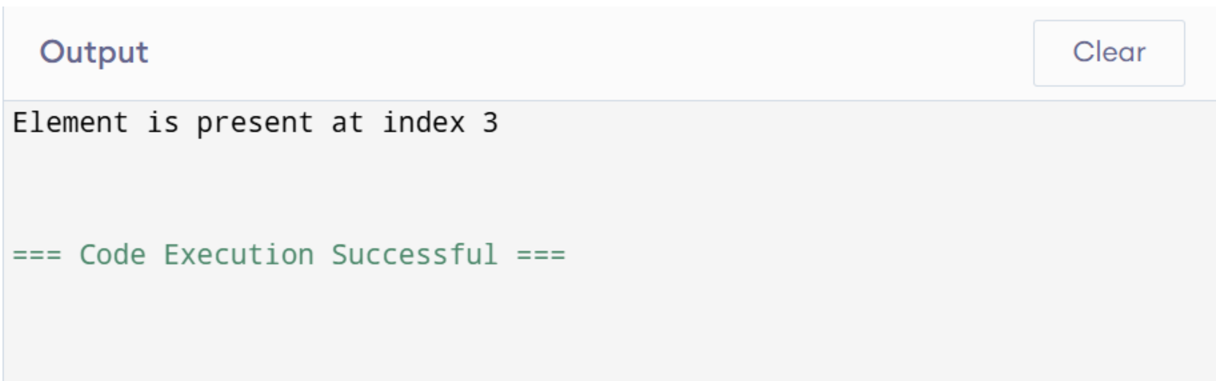
Output Clear

```
Sorted array: 5 6 7 11 12 13


=== Code Execution Successful ===
```

P4 Write a program to implement binary search on the given list of values.

```
#include <iostream>

using namespace std;


int binarySearch(int arr[], int l, int r, int x) {

   while (l <= r) {

      int mid = l + (r - l) / 2;


      if (arr[mid] == x)

         return mid;


      if (arr[mid] < x)

         l = mid + 1;

      else

         r = mid - 1;

   }

   return -1;

}


int main() {

   int arr[] = {2, 3, 4, 10, 40};

   int x = 10;

   int n = sizeof(arr) / sizeof(arr[0]);


   int result = binarySearch(arr, 0, n - 1, x);

   if (result == -1)
```

```
        cout << "Element is not present in array\n";
    else
        cout << "Element is present at index " << result << endl;

    return 0;
}
```



P5 Write a program to perform radix sort on a given list of numbers.

```
#include <iostream>
using namespace std;

int getMax(int arr[], int n) {
  int mx = arr[0];
  for (int i = 1; i < n; i++)
    if (arr[i] > mx)
      mx = arr[i];
  return mx;
}

void countSort(int arr[], int n, int exp) {
  int output[n];
  int count[10] = {0};

  for (int i = 0; i < n; i++)
    count[(arr[i] / exp) % 10]++;

  for (int i = 1; i < 10; i++)
    count[i] += count[i - 1];

  for (int i = n - 1; i >= 0; i--) {
    output[count[(arr[i] / exp) % 10] - 1] = arr[i];
    count[(arr[i] / exp) % 10]--;
  }
```

```
    for (int i = 0; i < n; i++)
        arr[i] = output[i];
}

void radixSort(int arr[], int n) {
    int m = getMax(arr, n);

    for (int exp = 1; m / exp > 0; exp *= 10)
        countSort(arr, n, exp);
}

void printArray(int arr[], int n) {
    for (int i = 0; i < n; i++)
        cout << arr[i] << " ";
    cout << endl;
}

int main() {
    int arr[] = {170, 45, 75, 90, 802, 24, 2, 66};
    int n = sizeof(arr) / sizeof(arr[0]);
    radixSort(arr, n);
    cout << "Sorted array: ";
    printArray(arr, n);
    return 0;
}
```

Output

Clear

```
Sorted array: 2 24 45 66 75 90 170 802


=== Code Execution Successful ===
```

P6 Write a program to perform bucket sort on a given list of numbers.

```
#include <iostream>

#include <vector>

#include <algorithm>

using namespace std;


void bucketSort(float arr[], int n) {

  vector<float> buckets[n];


  // 1. Put elements into different buckets

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

    int bucketIndex = n * arr[i];  // Index in bucket

    buckets[bucketIndex].push_back(arr[i]);

  }


  // 2. Sort each bucket individually

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

    sort(buckets[i].begin(), buckets[i].end());

  }


  // 3. Concatenate all buckets into the original array

  int index = 0;

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

    for (size_t j = 0; j < buckets[i].size(); j++) {

      arr[index++] = buckets[i][j];

    }
```

```
    }
}

void printArray(float arr[], int n) {
    for (int i = 0; i < n; i++)
        cout << arr[i] << " ";
    cout << endl;
}

int main() {
    float arr[] = {0.897, 0.565, 0.656, 0.1234, 0.665, 0.3434};
    int n = sizeof(arr) / sizeof(arr[0]);

    bucketSort(arr, n);

    cout << "Sorted array: ";
    printArray(arr, n);

    return 0;
}
```

Output

Clear

```
Sorted array: 0.1234 0.3434 0.565 0.656 0.665 0.897


=== Code Execution Successful ===
```

P7 Write a program to perform counting sort on a given list of numbers.

```
#include <iostream>
using namespace std;

void countSort(int arr[], int n) {
  // Find the maximum element in the array
  int max = arr[0];
  for (int i = 1; i < n; i++) {
    if (arr[i] > max) {
      max = arr[i];
    }
  }

  // Create a count array to store the count of individual elements
  int count[max + 1] = {0};

  // Store the count of each element
  for (int i = 0; i < n; i++) {
    count[arr[i]]++;
  }

  // Modify count array to store cumulative count
  for (int i = 1; i <= max; i++) {
    count[i] += count[i - 1];
  }
```

```
    // Output array to store sorted elements
    int output[n];
    for (int i = n - 1; i >= 0; i--) {
        output[count[arr[i]] - 1] = arr[i];
        count[arr[i]]--;
    }

    // Copy the sorted elements back into the original array
    for (int i = 0; i < n; i++) {
        arr[i] = output[i];
    }
}

void printArray(int arr[], int n) {
    for (int i = 0; i < n; i++)
        cout << arr[i] << " ";
    cout << endl;
}

int main() {
    int arr[] = {4, 2, 2, 8, 3, 3, 1};
    int n = sizeof(arr) / sizeof(arr[0]);

    countSort(arr, n);

    cout << "Sorted array: ";
```

```
    printArray(arr, n);

    return 0;
}
```

Output   Clear

```
Sorted array: 1 2 2 3 3 4 8


=== Code Execution Successful ===
```

P8 Given two matrices, perform Strassen's matrix multiplication.

```
#include <iostream>

using namespace std;


// Function to add two matrices

void add(int A[2][2], int B[2][2], int C[2][2]) {

   for (int i = 0; i < 2; i++) {

      for (int j = 0; j < 2; j++) {

         C[i][j] = A[i][j] + B[i][j];

      }

   }

}


// Function to subtract two matrices

void subtract(int A[2][2], int B[2][2], int C[2][2]) {

   for (int i = 0; i < 2; i++) {

      for (int j = 0; j < 2; j++) {

         C[i][j] = A[i][j] - B[i][j];

      }

   }

}


// Strassen's Matrix Multiplication

void strassen(int A[2][2], int B[2][2], int C[2][2]) {

   int M1 = (A[0][0] + A[1][1]) * (B[0][0] + B[1][1]);

   int M2 = (A[1][0] + A[1][1]) * B[0][0];
```

```
    int M3 = A[0][0] * (B[0][1] - B[1][1]);
    int M4 = A[1][1] * (B[1][0] - B[0][0]);
    int M5 = (A[0][0] + A[0][1]) * B[1][1];
    int M6 = (A[1][0] - A[0][0]) * (B[0][0] + B[0][1]);
    int M7 = (A[0][1] - A[1][1]) * (B[1][0] + B[1][1]);

    // Calculating the final values for C
    C[0][0] = M1 + M4 - M5 + M7;
    C[0][1] = M3 + M5;
    C[1][0] = M2 + M4;
    C[1][1] = M1 - M2 + M3 + M6;
}

int main() {
    int A[2][2] = { {1, 2}, {3, 4} };
    int B[2][2] = { {5, 6}, {7, 8} };
    int C[2][2]; // Result matrix

    // Applying Strassen's Algorithm
    strassen(A, B, C);

    cout << "Resultant Matrix C (A * B):" << endl;
    for (int i = 0; i < 2; i++) {
        for (int j = 0; j < 2; j++) {
            cout << C[i][j] << " ";
        }
```

```
        cout << endl;
    }

    return 0;
}
```

Output   Clear

```
Resultant Matrix C (A * B):
19 22
43 50


=== Code Execution Successful ===
```

P9 To Implement Matrix Chain Multiplication.

```
#include <iostream>
#include <climits> // For INT_MAX
using namespace std;

// Function to perform Matrix Chain Multiplication
int matrixChainMultiplication(int dims[], int n) {
   // Create a 2D table to store the minimum multiplication costs
   int dp[n][n];

   // Initialize the diagonal elements of dp to 0
   for (int i = 1; i < n; i++) {
      dp[i][i] = 0;
   }

   // l is the chain length
   for (int l = 2; l < n; l++) {
      for (int i = 1; i < n - l + 1; i++) {
         int j = i + l - 1;
         dp[i][j] = INT_MAX;

         // Try different places to split the product and calculate the cost
         for (int k = i; k < j; k++) {
            int cost = dp[i][k] + dp[k + 1][j] + dims[i - 1] * dims[k] * dims[j];

            // Update the minimum cost
```

```
            if (cost < dp[i][j]) {
                dp[i][j] = cost;
            }
        }
    }
}

// The minimum cost to multiply matrices A1...An-1 will be in dp[1][n-1]
return dp[1][n - 1];
}

int main() {
    // Array representing dimensions of matrices A1, A2, ..., An
    // If A1 is 10x30, A2 is 30x5, and A3 is 5x60, the array is {10, 30, 5, 60}
    int dims[] = {10, 30, 5, 60};
    int n = sizeof(dims) / sizeof(dims[0]);

    // Call the function
    int minCost = matrixChainMultiplication(dims, n);

    cout << "Minimum number of multiplications is " << minCost << endl;

    return 0;
}
```

Output

Clear

```
Minimum number of multiplications is 4500


=== Code Execution Successful ===
```

P10 Write a program to perform a naïve string matching algorithm.

```
#include <iostream>

#include <string>

using namespace std;


// Function to perform Naïve String Matching

void naiveStringMatching(string text, string pattern) {

  int n = text.length();

  int m = pattern.length();


  // Loop over each position in the text where pattern can potentially match

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

    int j;


    // Check the characters of the pattern with the text

    for (j = 0; j < m; j++) {

      if (text[i + j] != pattern[j]) {

        break;

      }

    }


    // If all characters match, we found the pattern at index i

    if (j == m) {

      cout << "Pattern found at index " << i << endl;

    }

  }
```

```
}

int main() {
    string text = "ABABDABACDABABCABAB";
    string pattern = "ABABCABAB";

    // Call the function
    naiveStringMatching(text, pattern);

    return 0;
}
```

Output   Clear

```
Pattern found at index 10


=== Code Execution Successful ===
```

P12 Implement fractional Knapsack using Greedy approach and analyze the algorithm.

```
#include <iostream>

#include <vector>

#include <algorithm>

using namespace std;


// Structure to store weight and value of an item

struct Item {

   int weight;

   int value;

};


// Comparator function to sort items by value-to-weight ratio

bool compare(Item a, Item b) {

   double r1 = (double)a.value / a.weight;

   double r2 = (double)b.value / b.weight;

   return r1 > r2; // Sort in descending order of value/weight

}


// Function to calculate the maximum value that can be obtained in a fractional knapsack

double fractionalKnapsack(int W, vector<Item> items, int n) {

   // Sort items by value-to-weight ratio

   sort(items.begin(), items.end(), compare);


   double totalValue = 0.0;  // Result (maximum value)
```

```
    // Iterate through all items
    for (int i = 0; i < n; i++) {
        // If the item can be included fully
        if (items[i].weight <= W) {
            W -= items[i].weight;      // Decrease the weight of the knapsack
            totalValue += items[i].value; // Add the item's value
        }
        // If only a fraction of the item can be included
        else {
            totalValue += items[i].value * ((double)W / items[i].weight); // Add fractional value
            break;  // Since the knapsack is full
        }
    }

    return totalValue;
}

int main() {
    int W = 50; // Knapsack capacity
    vector<Item> items = {{10, 60}, {20, 100}, {30, 120}}; // List of items with weights and
values

    int n = items.size();

    // Calculate and display the maximum value
    double maxValue = fractionalKnapsack(W, items, n);
```

```
    cout << "Maximum value in Knapsack = " << maxValue << endl;

    return 0;
}
```

Output   Clear

```
Maximum value in Knapsack = 240


=== Code Execution Successful ===
```

P13 To implement Huffman Coding and analyze its time complexity.

```
#include <iostream>

#include <queue>

#include <unordered_map>

#include <vector>

using namespace std;


// A node in the Huffman Tree

struct Node {

    char ch;        // Character

    int freq;       // Frequency of the character

    Node *left, *right;


    // Constructor

    Node(char c, int f) {

        ch = c;

        freq = f;

        left = right = nullptr;

    }

};


// Comparator to order nodes in the priority queue (min-heap)

struct Compare {

    bool operator()(Node* a, Node* b) {

        return a->freq > b->freq; // Min-heap based on frequency

    }

};
```

```
// Function to generate Huffman Codes from the tree
void generateCodes(Node* root, string code, unordered_map<char, string>& huffmanCodes) {
    if (!root) return;

    // If it's a leaf node, add the character and its code
    if (!root->left && !root->right) {
        huffmanCodes[root->ch] = code;
    }

    // Recur for left and right children
    generateCodes(root->left, code + "0", huffmanCodes);
    generateCodes(root->right, code + "1", huffmanCodes);
}

// Huffman Encoding Function
void huffmanCoding(vector<char> chars, vector<int> freqs) {
    int n = chars.size();

    // Step 1: Create a min-heap
    priority_queue<Node*, vector<Node*>, Compare> pq;

    // Step 2: Add all characters to the min-heap
    for (int i = 0; i < n; i++) {
        pq.push(new Node(chars[i], freqs[i]));
    }
```

```
    // Step 3: Build the Huffman Tree
    while (pq.size() > 1) {
        Node* left = pq.top(); pq.pop(); // Smallest freq
        Node* right = pq.top(); pq.pop(); // Second smallest freq

        // Create a new internal node with combined frequency
        Node* combined = new Node('\0', left->freq + right->freq);
        combined->left = left;
        combined->right = right;

        pq.push(combined); // Add the combined node back to the heap
    }

    // The remaining node is the root of the Huffman Tree
    Node* root = pq.top();

    // Step 4: Generate Huffman Codes
    unordered_map<char, string> huffmanCodes;
    generateCodes(root, "", huffmanCodes);

    // Step 5: Print the Huffman Codes
    cout << "Huffman Codes:" << endl;
    for (auto pair : huffmanCodes) {
        cout << pair.first << ": " << pair.second << endl;
    }
}
```

```
// Main function
int main() {
    vector<char> chars = {'a', 'b', 'c', 'd', 'e'};
    vector<int> freqs = {5, 9, 12, 13, 16};

    huffmanCoding(chars, freqs);

    return 0;
}
```

Output Clear

```
Huffman Codes:
e: 11
b: 101
a: 100
d: 01
c: 00
```

P14 Implement the Dijkstra Algorithm using Greedy and analyze the algorithm.

```
#include <iostream>

#include <vector>

#include <queue>

#include <utility>

#include <climits>


using namespace std;


// Function to implement Dijkstra's Algorithm

vector<int> dijkstra(int V, vector<vector<pair<int, int>>>& graph, int src) {

  vector<int> dist(V, INT_MAX);

  dist[src] = 0;


  priority_queue<pair<int, int>, vector<pair<int, int>>, greater<pair<int, int>>> pq;

  pq.push({0, src}); // (distance, vertex)


  while (!pq.empty()) {

    int u = pq.top().second;

    pq.pop();


    // Traverse all adjacent vertices

    for (auto& neighbor : graph[u]) {

      int v = neighbor.first;

      int weight = neighbor.second;
```

```
            // Relaxation step
            if (dist[u] + weight < dist[v]) {
                dist[v] = dist[u] + weight;
                pq.push({dist[v], v});
            }
        }
    }

    return dist;
}

// Main function to demonstrate Dijkstra's algorithm
int main() {
    int V = 5; // Number of vertices
    vector<vector<pair<int, int>>> graph(V);

    // Adding edges (u, v, weight)
    graph[0].emplace_back(1, 10);
    graph[0].emplace_back(4, 5);
    graph[1].emplace_back(2, 1);
    graph[2].emplace_back(3, 2);
    graph[4].emplace_back(1, 3);
    graph[4].emplace_back(2, 9);
    graph[4].emplace_back(3, 2);
    graph[3].emplace_back(2, 6);
```

```
    vector<int> distances = dijkstra(V, graph, 0);

    cout << "Vertex Distance from Source\n";
    for (int i = 0; i < V; i++) {
        cout << i << "\t\t" << distances[i] << endl;
    }

    return 0;
}
```

Output Clear

```
Vertex Distance from Source
0		0
1		8
2		9
3		7
4		5


=== Code Execution Successful ===
```

P15 Implement the Prims' and Kruskal Algorithm using Greedy and analyze the algorithm.

```
#include <iostream>

#include <vector>

#include <queue>

#include <utility>

#include <climits>


using namespace std;


// Function to implement Prim's Algorithm

void prim(int V, vector<vector<pair<int, int>>>& graph) {

  vector<int> key(V, INT_MAX);

  vector<bool> inMST(V, false);

  priority_queue<pair<int, int>, vector<pair<int, int>>, greater<pair<int, int>>> pq;


  key[0] = 0; // Starting vertex

  pq.push({0, 0}); // (key, vertex)


  while (!pq.empty()) {

    int u = pq.top().second;

    pq.pop();

    inMST[u] = true; // Include vertex in MST


    // Traverse all adjacent vertices

    for (auto& neighbor : graph[u]) {
```

```
            int v = neighbor.first;
            int weight = neighbor.second;

            // If not in MST and weight is less than key
            if (!inMST[v] && weight < key[v]) {
                key[v] = weight;
                pq.push({key[v], v});
            }
        }
    }

    // Output the total weight of the MST
    int totalWeight = 0;
    for (int i = 0; i < V; i++) {
        totalWeight += key[i];
    }
    cout << "Total weight of MST using Prim's: " << totalWeight << endl;
}

// Main function to demonstrate Prim's algorithm
int main() {
    int V = 5; // Number of vertices
    vector<vector<pair<int, int>>> graph(V);

    // Adding edges (u, v, weight)
    graph[0].emplace_back(1, 2);
```

```
    graph[0].emplace_back(3, 6);
    graph[1].emplace_back(0, 2);
    graph[1].emplace_back(2, 3);
    graph[1].emplace_back(3, 8);
    graph[1].emplace_back(4, 5);
    graph[2].emplace_back(1, 3);
    graph[2].emplace_back(4, 7);
    graph[3].emplace_back(0, 6);
    graph[3].emplace_back(1, 8);
    graph[4].emplace_back(1, 5);
    graph[4].emplace_back(2, 7);

    prim(V, graph);

    return 0;
}
```

Output   Clear

```
Total weight of MST using Prim's: 16


=== Code Execution Successful ===
```

Kruskal

```
#include <iostream>

#include <vector>

#include <algorithm>

using namespace std;


// Structure to represent an edge

struct Edge {

   int src, dest, weight;

   Edge(int s, int d, int w) : src(s), dest(d), weight(w) {}

};


// Comparator to sort edges by weight

bool compareEdges(Edge a, Edge b) {

   return a.weight < b.weight;

}


// Find function for Union-Find (with path compression)

int findParent(int node, vector<int>& parent) {

   if (parent[node] == node) {

      return node;

   }

   return parent[node] = findParent(parent[node], parent); // Path compression

}


// Union function for Union-Find
```

```
void unionSets(int u, int v, vector<int>& parent, vector<int>& rank) {
   int rootU = findParent(u, parent);
   int rootV = findParent(v, parent);

   if (rootU != rootV) {
      if (rank[rootU] < rank[rootV]) {
         parent[rootU] = rootV;
      } else if (rank[rootU] > rank[rootV]) {
         parent[rootV] = rootU;
      } else {
         parent[rootV] = rootU;
         rank[rootU]++;
      }
   }
}

// Kruskal's Algorithm
void kruskal(int V, vector<Edge>& edges) {
   // Step 1: Sort all edges by weight
   sort(edges.begin(), edges.end(), compareEdges);

   // Initialize Union-Find data structures
   vector<int> parent(V);
   vector<int> rank(V, 0);
   for (int i = 0; i < V; i++) {
      parent[i] = i;
```

```
    }

    // Resultant MST
    vector<Edge> mst;
    int mstCost = 0;

    // Step 2: Process edges in sorted order
    for (Edge& edge : edges) {
        int u = edge.src;
        int v = edge.dest;

        // Check if adding this edge creates a cycle
        if (findParent(u, parent) != findParent(v, parent)) {
            mst.push_back(edge);
            mstCost += edge.weight;
            unionSets(u, v, parent, rank);
        }
    }

    // Step 3: Output the MST
    cout << "Edges in the Minimum Spanning Tree:" << endl;
    for (Edge& edge : mst) {
        cout << edge.src << " -- " << edge.dest << " == " << edge.weight << endl;
    }
    cout << "Total Cost of MST: " << mstCost << endl;
}
```

```
int main() {
    int V = 5; // Number of vertices
    vector<Edge> edges;

    // Graph edges (src, dest, weight)
    edges.push_back(Edge(0, 1, 10));
    edges.push_back(Edge(0, 2, 6));
    edges.push_back(Edge(0, 3, 5));
    edges.push_back(Edge(1, 3, 15));
    edges.push_back(Edge(2, 3, 4));

    kruskal(V, edges);

    return 0;
}
```

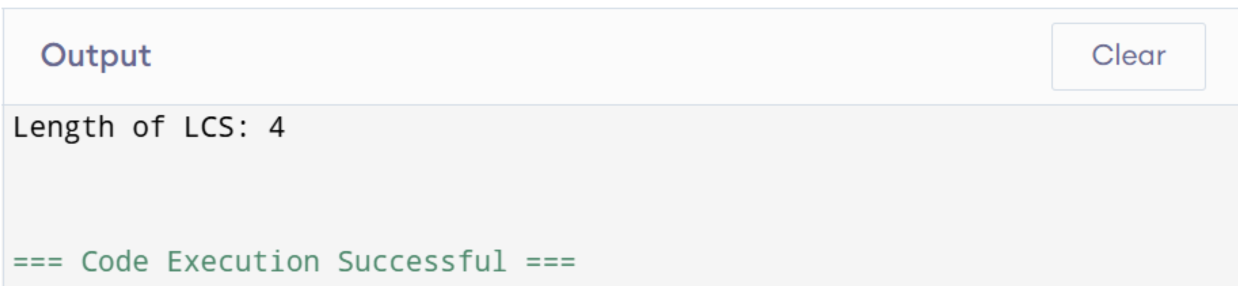
Output   Clear

```
Edges in the Minimum Spanning Tree:
2 -- 3 == 4
0 -- 3 == 5
0 -- 1 == 10
Total Cost of MST: 19
```

P16 Implement the Longest Common Subsequence using Dynamic Programming and analyze the algorithm.

```
#include <iostream>

#include <vector>

#include <string>


using namespace std;


// Function to find LCS using Dynamic Programming

int lcs(const string& s1, const string& s2) {

  int m = s1.length();

  int n = s2.length();

  vector<vector<int>> dp(m + 1, vector<int>(n + 1, 0));


  // Build the dp table

  for (int i = 1; i <= m; i++) {

    for (int j = 1; j <= n; j++) {

      if (s1[i - 1] == s2[j - 1]) {

        dp[i][j] = dp[i - 1][j - 1] + 1; // If characters match

      } else {

        dp[i][j] = max(dp[i - 1][j], dp[i][j - 1]); // If not

      }

    }

  }


  return dp[m][n]; // Length of LCS
```

```
}

// Main function to demonstrate LCS
int main() {
   string s1 = "AGGTAB";
   string s2 = "GXTXAYB";
   cout << "Length of LCS: " << lcs(s1, s2) << endl;
   return 0;
}
```



}

P17 Implement Matrix Chain Multiplication using Dynamic Programming and analyze the algorithm

```
#include <iostream>

#include <vector>

#include <limits.h>


using namespace std;


// Function to find the minimum number of multiplications

int matrixChainOrder(const vector<int>& p) {

  int n = p.size() - 1; // Number of matrices

  vector<vector<int>> dp(n, vector<int>(n, 0));


  // L is the chain length

  for (int L = 2; L <= n; L++) {

    for (int i = 0; i < n - L + 1; i++) {

      int j = i + L - 1;

      dp[i][j] = INT_MAX;


      // Calculate the minimum cost

      for (int k = i; k < j; k++) {

        int q = dp[i][k] + dp[k + 1][j] + p[i] * p[k + 1] * p[j + 1];

        dp[i][j] = min(dp[i][j], q);

      }

    }

  }
```

```
    return dp[0][n - 1]; // Minimum cost
}

// Main function to demonstrate Matrix Chain Multiplication
int main() {
    vector<int> p = {1, 2, 3, 4}; // Dimensions
    cout << "Minimum number of multiplications: " << matrixChainOrder(p) << endl;
    return 0;
}
```

Output Clear

```
Minimum number of multiplications: 18


=== Code Execution Successful ===
```

P18 Implement Floyd-Warshell algorithm for a given graph.

```
#include <iostream>

#include <vector>

#include <limits.h>


using namespace std;


// Function to implement Floyd-Warshall Algorithm

void floydWarshall(vector<vector<int>>& graph) {

   int V = graph.size();


   // Updating distances

   for (int k = 0; k < V; k++) {

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

         for (int j = 0; j < V; j++) {

            if (graph[i][k] != INT_MAX && graph[k][j] != INT_MAX) {

               graph[i][j] = min(graph[i][j], graph[i][k] + graph[k][j]);

            }

         }

      }

   }

}


// Main function to demonstrate Floyd-Warshall Algorithm

int main() {

   vector<vector<int>> graph = {
```

```
        {0, 5, INT_MAX, 10},
        {INT_MAX, 0, 3, INT_MAX},
        {INT_MAX, INT_MAX, 0, 1},
        {INT_MAX, INT_MAX, INT_MAX, 0}
    };

    floydWarshall(graph);

    cout << "Shortest distances between every pair of vertices:\n";
    for (const auto& row : graph) {
        for (int dist : row) {
            if (dist == INT_MAX) cout << "INF ";
            else cout << dist << " ";
        }
        cout << endl;
    }

    return 0;
}
```

Output Clear

```
Shortest distances between every pair of vertices:
0 5 8 9
INF 0 3 4
INF INF 0 1
INF INF INF 0


=== Code Execution Successful ===
```