**1. Write program to implement basic operations of Binary Search Tree.**

**Algorithm:**

1. **Insertion**:  
   **Step 1**: If the tree is empty, create a new node as the root.   
   **Step 2**: If the value < current node’s data, recursively insert into the left subtree. **Step 3**: If the value > current node’s data, recursively insert into the right subtree.
2. **Traversal**:   
   **Inorder**: Traverse left → visit root → traverse right.   
   **Preorder**: Visit root → traverse left → traverse right.   
   **Postorder**: Traverse left → traverse right → visit root.
3. **Deletion**:

**Case 1**: Node has no children → Delete directly.

**Case 2**: Node has one child → Replace with its child.

**Case 3**: Node has two children → Replace with its in order successor, then delete the successor.

**Example:**

1. Insert: 50, 30, 70, 20, 40, 60, 80.
2. Inorder Traversal: 20 30 40 50 60 70 80.
3. Delete 20 (leaf node).
4. Delete 30 (node with one child).
5. Delete 50 (root with two children).

Inorder after deletions: 40 60 70 80

**Program:**

#include <stdio.h>

#include <stdlib.h>

// BST Node structure

typedef struct Node {

int data;

struct Node \* left, \* right;

}

Node;

// Create a new node

Node \* createNode(int value) {

Node \* newNode = (Node \* ) malloc(sizeof(Node));

newNode -> data = value;

newNode -> left = newNode -> right = NULL;

return newNode;

}

// Insert a node into BST

Node \* insert(Node \* root, int value) {

if (root == NULL) return createNode(value);

if (value < root -> data) root -> left = insert(root -> left, value);

else if (value > root -> data) root -> right = insert(root -> right, value);

return root;

}

// Find inorder successor (smallest in right subtree)

Node \* minValueNode(Node \* node) {

Node \* current = node;

while (current && current -> left != NULL) current = current -> left;

return current;

}

// Delete a node from BST

Node \* deleteNode(Node \* root, int value) {

if (root == NULL) return root;

if (value < root -> data) root -> left = deleteNode(root -> left, value);

else if (value > root -> data) root -> right = deleteNode(root -> right, value);

else {

// Node with one or no child

if (root -> left == NULL) {

Node \* temp = root -> right;

free(root);

return temp;

} else if (root -> right == NULL) {

Node \* temp = root -> left;

free(root);

return temp;

}

// Node with two children: replace with inorder successor

Node \* temp = minValueNode(root -> right);

root -> data = temp -> data;

root -> right = deleteNode(root -> right, temp -> data);

}

return root;

}

// Inorder traversal

void inorder(Node \* root) {

if (root != NULL) {

inorder(root -> left);

printf("%d ", root -> data);

inorder(root -> right);

}

}

int main() {

Node \* root = NULL;

root = insert(root, 50);

insert(root, 30);

insert(root, 70);

insert(root, 20);

insert(root, 40);

insert(root, 60);

insert(root, 80);

printf("Inorder after insertion: ");

inorder(root);

printf("\n");

root = deleteNode(root, 20);

root = deleteNode(root, 30);

root = deleteNode(root, 50);

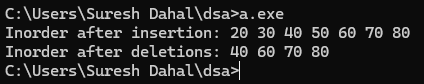
printf("Inorder after deletions: ");

inorder(root);

return 0;

}

**Output:**



**2. Write programs to implement sorting algorithms: Bubble, Insertion, Selection, Merge and Quick**

# Bubble Sort

**Algorithm:**

1. **Step 1**: Start with the first element. Compare it with the next element.
2. **Step 2**: If the current element > next element, swap them.
3. **Step 3**: Move to the next pair and repeat Step 2 for all adjacent pairs in the array.
4. **Step 4**: Repeat Steps 1-3 for n-1 passes (where n is the array size).
5. **Step 5**: If no swaps occur in a pass, the array is sorted.

**Example:**

**Input Array**: [4, 2, 0, 1, 3]

**Pass 1:**

• Compare 4 & 2 → swap → [2, 4, 0, 1, 3]

• Compare 4 & 0 → swap → [2, 0, 4, 1, 3]

• Compare 4 & 1 → swap → [2, 0, 1, 4, 3]

• Compare 4 & 3 → swap → [2, 0, 1, 3, 4]

**Pass 2:**

• Compare 2 & 0 → swap → [0, 2, 1, 3, 4]

• Compare 2 & 1 → swap → [0, 1, 2, 3, 4]

• Compare 2 & 3 → no swap

• No further swaps

**Pass 3:**

• Compare 0 & 1 → no swap

• Compare 1 & 2 → no swap

• No swaps → Sorting stops early.

**Output**: [0, 1, 2, 3, 4]

**Program**:

#include <stdio.h>

void bubbleSort(int arr[], int n) {

int swapped;

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

swapped = 0;

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

if (arr[j] > arr[j + 1]) {

// Swap elements

int temp = arr[j];

arr[j] = arr[j + 1];

arr[j + 1] = temp;

swapped = 1;

}

}

// Early termination if no swaps

if (swapped == 0) break;

}

}

int main() {

int arr[] = { 4,2,0,1,3 };

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

printf("Original array: ");

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

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

bubbleSort(arr, n);

printf("\nSorted array: ");

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

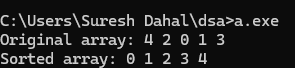
printf("%d ", arr[i]);

}

return 0;

}

**Output:**



# Insertion Sort

**Algorithm:**

**Step 1:** Start with the second element in the array. Compare it with the first element.

**Step 2:** If the current element is smaller than the previous element, shift the previous elements to the right to make space for the current element.

**Step 3:** Insert the current element into the correct position.

**Step 4:** Move to the next element and repeat steps 2-3 for all elements in the array.

**Step 5:** Continue until all elements have been inserted into their correct positions.

**Example:**

**Input Array:** [4, 2, 0, 1, 3]

**Pass 1:**   
Compare 2 with 4 → 2 is smaller → shift 4 → [4, 4, 0, 1, 3]  
Insert 2 → [2, 4, 0, 1, 3]

**Pass 2:**   
Compare 0 with 4 → 0 is smaller → shift 4 → [2, 4, 4, 1, 3]  
Compare 0 with 2 → 0 is smaller → shift 2 → [2, 2, 4, 1, 3]  
Insert 0 → [0, 2, 4, 1, 3]

**Pass 3:**   
Compare 1 with 4 → 1 is smaller → shift 4 → [0, 2, 4, 4, 3]  
Compare 1 with 2 → 1 is smaller → shift 2 → [0, 2, 2, 4, 3]  
Insert 1 → [0, 1, 2, 4, 3]

**Pass 4:**   
Compare 3 with 4 → 3 is smaller → shift 4 → [0, 1, 2, 4, 4]  
Insert 3 → [0, 1, 2, 3, 4]

**Output:** [0, 1, 2, 3, 4]

**Program:**

#include <stdio.h>

// Recursive function to perform insertion sort

void insertionSort(int arr[], int n) {

// Base case: if there is only one element or no elements, return

if (n <= 1) {

return;

}

// Sort first n-1 elements

insertionSort(arr, n - 1);

// Insert the nth element in the sorted part of the array

int last = arr[n - 1];

int j = n - 2;

while (j >= 0 && arr[j] > last) {

arr[j + 1] = arr[j];

j--;

}

arr[j + 1] = last;

}

// Function to print the array

void printArray(int arr[], int n) {

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

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

}

printf("\n");

}

int main() {

int arr[] = {4,2,0,1,3};

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

printf("Original array: ");

printArray(arr, n);

insertionSort(arr, n);

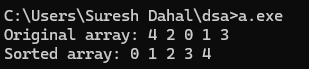
printf("Sorted array: ");

printArray(arr, n);

return 0;

}

**Output:**



# Selection Sort

**Algorithm:**

**Step 1:** Start with the first element. Find the smallest element in the remaining unsorted part of the array.

**Step 2:** Swap the smallest element with the first element.

**Step 3:** Move to the next element and repeat steps 1-2 for all elements except the last one (as it will be automatically sorted).

**Step 4:** Continue until the entire array is sorted.

**Example:**

**Input Array:** [4, 2, 0, 1, 3]

**Pass 1:**  
Find the smallest element in the array [4, 2, 0, 1, 3] → smallest is 0.  
Swap 4 and 0 → [0, 2, 4, 1, 3]

**Pass 2:**  
Find the smallest element in the remaining array [2, 4, 1, 3] → smallest is 1.  
Swap 2 and 1 → [0, 1, 4, 2, 3]

**Pass 3:**  
Find the smallest element in the remaining array [4, 2, 3] → smallest is 2.  
Swap 4 and 2 → [0, 1, 2, 4, 3]

**Pass 4:**  
Find the smallest element in the remaining array [4, 3] → smallest is 3.  
Swap 4 and 3 → [0, 1, 2, 3, 4]

**Output:** [0, 1, 2, 3, 4]

**Program:**

#include <stdio.h>

void selectionSort(int arr[], int n) {

int minIndex, temp;

// Move through the entire array

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

// Find the smallest element in the unsorted part of the array

minIndex = i;

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

if (arr[j] < arr[minIndex]) {

minIndex = j;

}

}

// Swap the found smallest element with the first element of the unsorted part

if (minIndex != i) {

temp = arr[i];

arr[i] = arr[minIndex];

arr[minIndex] = temp;

}

}

}

// Function to print the array

void printArray(int arr[], int n) {

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

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

}

printf("\n");

}

int main() {

int arr[] = { 4,2,0,1,3 };

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

printf("Original array: ");

printArray(arr, n);

selectionSort(arr, n);

printf("Sorted array: ");

printArray(arr, n);

return 0;

}

**Output:**



# Merge Sort

**Algorithm:**

**Step 1:** Divide the array into two halves.

**Step 2:** Recursively apply the merge sort to both halves until you reach subarrays of size 1.

**Step 3:** Merge the two sorted halves back together into a single sorted array.

**Step 4:** Repeat steps 1-3 until the entire array is sorted.

**Example:**

**Input Array:** [4, 2, 0, 1, 3]  
**Step 1: Divide the array into two halves:**  
• Left half: [4, 2, 0]  
• Right half: [1, 3]

**Step 2: Recursively sort both halves:  
Sorting [4, 2, 0]:**  
• Divide into [4] and [2, 0]  
• Sort [2, 0]:

* Divide into [2] and [0]
* Merge [2] and [0] → [0, 2]  
  • Merge [4] and [0, 2] → [0, 2, 4]

**Sorting [1, 3]:**  
• [1] and [3] are already sorted.

**Step 3: Merge [0, 2, 4] and [1, 3]:**  
• Merging gives: [0, 1, 2, 3, 4]

**Output:** [0, 1, 2, 3, 4]

**Program:**

#include <stdio.h>

void merge(int arr[], int left, int mid, int right) {

int n1 = mid - left + 1;

int n2 = right - mid;

// Create temporary arrays

int leftArr[n1], rightArr[n2];

// Copy data to temporary arrays

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

leftArr[i] = arr[left + i];

for (int j = 0; j < n2; j++)

rightArr[j] = arr[mid + 1 + j];

int i = 0, j = 0, k = left;

// Merge the temporary arrays back into the original array

while (i < n1 && j < n2) {

if (leftArr[i] <= rightArr[j]) {

arr[k] = leftArr[i];

i++;

} else {

arr[k] = rightArr[j];

j++;

}

k++;

}

// Copy the remaining elements of leftArr[] if any

while (i < n1) {

arr[k] = leftArr[i];

i++;

k++;

}

// Copy the remaining elements of rightArr[] if any

while (j < n2) {

arr[k] = rightArr[j];

j++;

k++;

}

}

// Function to perform merge sort

void mergeSort(int arr[], int left, int right) {

if (left < right) {

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

// Recursively sort the first and second halves

mergeSort(arr, left, mid);

mergeSort(arr, mid + 1, right);

// Merge the sorted halves

merge(arr, left, mid, right);

}

}

void printArray(int arr[], int n) {

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

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

}

printf("\n");

}

int main() {

int arr[] = {4,2,0,1,3};

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

printf("Original array: ");

printArray(arr, n);

mergeSort(arr, 0, n - 1);

printf("Sorted array: ");

printArray(arr, n);

return 0;

}

**Output:**



# Quick Sort

**Algorithm:**

**Step 1:** Choose a "pivot" element from the array. Different strategies can be used to choose the pivot (e.g., first element, last element, or middle element).

**Step 2:** Partition the array into two subarrays:

* Left subarray contains elements less than the pivot.
* Right subarray contains elements greater than the pivot.

**Step 3:** Recursively apply the quick sort to the left and right subarrays.

**Step 4:** Repeat steps 1-3 until the entire array is sorted.

**Example:**

**Input Array:** [4, 2, 0, 1, 3]

**Step 1: Choose a pivot.**  
Let's choose the last element (3) as the pivot.

**Step 2: Partition the array into:**  
• Left subarray: [2, 0, 1] (all elements less than 3)  
• Right subarray: [4] (all elements greater than 3)

**Step 3: Apply Quick Sort to [2, 0, 1]:**  
• Choose 1 as the pivot.  
• Partition into: [0] (less than 1) and [2] (greater than 1).

**Step 4: Combine sorted subarrays:**  
• Merge [0, 1, 2] with the pivot 3, followed by [4] → [0, 1, 2, 3, 4].

**Output:** [0, 1, 2, 3, 4]

**Program:**

#include <stdio.h>

// Function to partition the array

int partition(int arr[], int low, int high) {

int pivot = arr[high]; // Choose the last element as the pivot

int i = (low - 1); // Index of smaller element

for (int j = low; j < high; j++) {

if (arr[j] < pivot) { // If current element is smaller than the pivot

i++;

// Swap arr[i] and arr[j]

int temp = arr[i];

arr[i] = arr[j];

arr[j] = temp;

}

}

// Swap the pivot element with arr[i + 1] to place it in the correct position

int temp = arr[i + 1];

arr[i + 1] = arr[high];

arr[high] = temp;

return (i + 1); // Return the pivot index

}

// Function to perform quick sort

void quickSort(int arr[], int low, int high) {

if (low < high) {

int pi = partition(arr, low, high); // Partitioning index

// Recursively sort the two subarrays

quickSort(arr, low, pi - 1); // Left of pivot

quickSort(arr, pi + 1, high); // Right of pivot

}

}

// Function to print the array

void printArray(int arr[], int n) {

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

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

}

printf("\n");

}

int main() {

int arr[] = {4,2,0,1,3};

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

printf("Original array: ");

printArray(arr, n);

quickSort(arr, 0, n - 1);

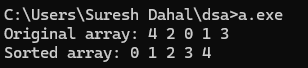
printf("Sorted array: ");

printArray(arr, n);

return 0;

}

**Output:**



**7. Write programs to implement Binary and Sequential Search.**

# Binary Search

**Algorithm:**

**Step 1:** Start with the middle element of the array.

**Step 2:** Compare the middle element with the target value.

* If the target is equal to the middle element, the search is complete, and the index of the middle element is returned.
* If the target is less than the middle element, search the left half of the array.
* If the target is greater than the middle element, search the right half of the array.

**Step 3:** Repeat the above steps until the element is found or the search interval is empty.

**Example:**

**Input Array:** [0, 1, 2, 3, 4]  
  
**Target:** 3

• Start by comparing the middle element (2) with the target (3).

* The target is greater than 2, so search the right half of the array: [3, 4].

• Next, compare the middle element (3) with the target (3).

* The target is found at index 3.

**Output:** Index 3

**Program:**

#include <stdio.h>

// Function to implement binary search

int binarySearch(int arr[], int size, int target) {

int left = 0;

int right = size - 1;

while (left <= right) {

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

// Check if the target is present at mid

if (arr[mid] == target) {

return mid; // Target found, return the index

}

// If target is smaller than mid, it is in the left subarray

if (arr[mid] > target) {

right = mid - 1;

}

// If target is larger than mid, it is in the right subarray

else {

left = mid + 1;

}

}

return -1; // Target not found

}

// Function to print the array

void printArray(int arr[], int size) {

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

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

}

printf("\n");

}

int main() {

int arr[] = {0,1,2,3,4};

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

int target;

printf("Enter the target value: ");

scanf("%d", & target);

int result = binarySearch(arr, size, target);

if (result != -1) {

printf("Element found at index %d\n", result);

} else {

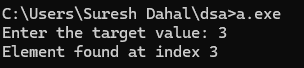
printf("Element not found in the array\n");

}

return 0;

}

**Output:**



# Sequential Searching

**Algorithm:**

**Step 1:** Start from the first element of the array.

**Step 2:** Compare the current element with the target value.

* If the current element matches the target, return the index of that element.
* If the current element does not match, move to the next element.

**Step 3:** Repeat steps 1-2 for all elements in the array until the target is found or the end of the array is reached.

**Step 4:** If the target is not found by the end of the array, return -1.

**Example:**

**Input Array:** [4, 2, 0, 1, 3]

**Target:** 3

• Start by comparing the first element (4) with the target (3).

* The target is not 4, move to the next element (2).  
  • The target is not 2, move to the next element (0).  
  • The target is not 0, move to the next element (1).  
  • The target is not 1, move to the next element (3).  
  • The target is 3, found at index 4.

**Output:** Index 4

**Program:**

#include <stdio.h>

// Function to implement sequential search

int sequentialSearch(int arr[], int size, int target) {

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

if (arr[i] == target) {

return i; // Return the index where target is found

}

}

return -1; // Target not found

}

// Function to print the array

void printArray(int arr[], int size) {

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

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

}

printf("\n");

}

int main() {

int arr[] = {4,2,0,1,3};

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

int target;

printf("Enter the target value: ");

scanf("%d", & target);

int result = sequentialSearch(arr, size, target);

if (result != -1) {

printf("Element found at index %d\n", result);

} else {

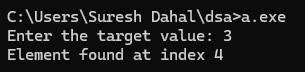
printf("Element not found in the array\n");

}

return 0;

}

**Output:**



**8. Write programs to implement search, spanning tree and shortest path algorithm in graph**

# Searching: Depth First Search (DFS) and Breadth First Search (BFS)

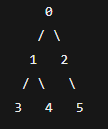
**BFS Algorithm:**

1. **Step 1**: Initialize a queue and enqueue the root node.
2. **Step 2**: While the queue is not empty:
   * **Step 2a**: Dequeue a node and visit it.
   * **Step 2b**: Enqueue its left child (if exists).
   * **Step 2c**: Enqueue its right child (if exists).

**DFS Algorithm:**

1. **Step 1**: Visit the current node.
2. **Step 2**: Recursively traverse the left subtree.
3. **Step 3**: Recursively traverse the right subtree.

**Example:**



**BFS Output:** [0, 1, 2, 3, 4, 5]

**DFS Output:** [0, 1, 3, 4, 2, 5]

**Program:**

#include <stdio.h>

#include <stdlib.h>

// Tree Node structure

typedef struct Node {

int data;

struct Node \*left, \*right;

} Node;

// Queue structure for BFS

typedef struct Queue {

Node \*\*array;

int front, rear, size;

} Queue;

// Create a new node

Node\* createNode(int data) {

Node\* newNode = (Node\*)malloc(sizeof(Node));

newNode->data = data;

newNode->left = newNode->right = NULL;

return newNode;

}

// Initialize queue

Queue\* createQueue(int size) {

Queue\* q = (Queue\*)malloc(sizeof(Queue));

q->array = (Node\*\*)malloc(size \* sizeof(Node\*));

q->front = q->rear = -1;

q->size = size;

return q;

}

// Enqueue a node

void enqueue(Queue\* q, Node\* node) {

if (q->rear == q->size - 1) return;

q->array[++q->rear] = node;

if (q->front == -1) q->front = 0;

}

// Dequeue a node

Node\* dequeue(Queue\* q) {

if (q->front == -1) return NULL;

Node\* temp = q->array[q->front];

if (q->front == q->rear) q->front = q->rear = -1;

else q->front++;

return temp;

}

// BFS Traversal

void BFS(Node\* root) {

if (root == NULL) return;

Queue\* q = createQueue(15); // Assuming max 15 nodes

enqueue(q, root);

while (q->front != -1) {

Node\* current = dequeue(q);

printf("%d ", current->data);

if (current->left != NULL) enqueue(q, current->left);

if (current->right != NULL) enqueue(q, current->right);

}

free(q->array);

free(q);

}

// DFS Traversal (Recursive)

void DFS(Node\* root) {

if (root == NULL) return;

printf("%d ", root->data);

DFS(root->left);

DFS(root->right);

}

// Build the tree (as per the example)

Node\* buildTree() {

Node\* root = createNode(0);

root->left = createNode(1);

root->right = createNode(2);

root->left->left = createNode(3);

root->left->right = createNode(4);

root->right->right = createNode(5);

return root;

}

int main() {

Node\* root = buildTree();

printf("BFS Traversal: ");

BFS(root);

printf("\nDFS Traversal: ");

DFS(root);

return 0;

}

**Output:**



# Minimum Spanning Tree: Prim’s and Kruskal Algorithms

A. Prim's Algorithm:

**Step 1**: Initialize a key array to store minimum weights and a boolean array to track included vertices.

**Step 2**: Start from an arbitrary vertex (e.g., vertex 0). Set its key to 0.

**Step 3**: For V-1 iterations:

Pick the vertex with the minimum key not yet included in the MST.

Update keys of adjacent vertices if a smaller edge weight is found.

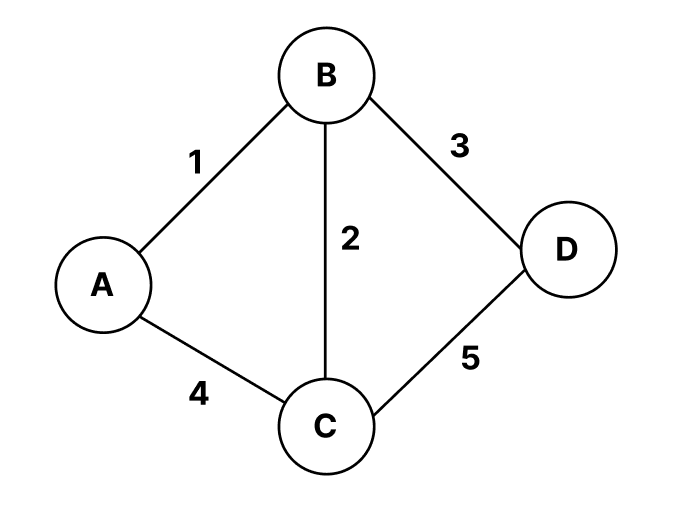
B. Kruskal's Algorithm:

**Step 1**: Sort all edges in ascending order of weight.

**Step 2**: Use Union-Find to add edges to the MST, ensuring no cycles.

**Step 3**: Stop when V-1 edges are added.

**Example:**



**Kruskal’s MST**: A-B (1), B-C (2), B-D (3) with total weight 6

**Prim’s MST**: A-B (1), B-C (2), B-D (3) with total weight 6

**Program:**

#include <stdio.h>

#include <stdlib.h>

#include <limits.h>

#define V 4 // Number of vertices

#define INF INT\_MAX

// ---------------------- Prim's Algorithm ----------------------

void primMST(int graph[V][V]) {

int parent[V], key[V], mstSet[V];

// Initialize all key values to INF and mstSet[] to false

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

key[i] = INF;

mstSet[i] = 0;

}

key[0] = 0; // Start from vertex A (0th index)

parent[0] = -1;

// Find the MST (V - 1) edges

for (int count = 0; count < V - 1; count++) {

int u, min = INF;

// Find the vertex with the minimum key value that is not yet included in MST

for (int v = 0; v < V; v++)

if (!mstSet[v] && key[v] < min)

min = key[v], u = v;

mstSet[u] = 1; // Include this vertex in MST

// Update key values of the adjacent vertices of the selected vertex

for (int v = 0; v < V; v++)

if (graph[u][v] && !mstSet[v] && graph[u][v] < key[v])

parent[v] = u, key[v] = graph[u][v];

}

// Print the MST edges

printf("Prim's MST Edges:\n");

for (int i = 1; i < V; i++)

printf("%c - %c (Weight %d)\n", parent[i] + 'A', i + 'A', graph[i][parent[i]]);

}

// ---------------------- Kruskal's Algorithm ----------------------

struct Edge {

int src, dest, weight;

};

struct subset {

int parent, rank;

};

int find(struct subset subsets[], int i) {

if (subsets[i].parent != i)

subsets[i].parent = find(subsets, subsets[i].parent);

return subsets[i].parent;

}

void Union(struct subset subsets[], int x, int y) {

int xroot = find(subsets, x);

int yroot = find(subsets, y);

if (subsets[xroot].rank < subsets[yroot].rank)

subsets[xroot].parent = yroot;

else {

subsets[yroot].parent = xroot;

if (subsets[xroot].rank == subsets[yroot].rank)

subsets[xroot].rank++;

}

}

int compare(const void\* a, const void\* b) {

return ((struct Edge\*)a)->weight - ((struct Edge\*)b)->weight;

}

void kruskalMST(struct Edge edges[], int E) {

qsort(edges, E, sizeof(edges[0]), compare);

struct subset\* subsets = (struct subset\*)malloc(V \* sizeof(struct subset));

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

subsets[v].parent = v;

subsets[v].rank = 0;

}

struct Edge result[V];

int e = 0, i = 0;

while (e < V - 1 && i < E) {

struct Edge next = edges[i++];

int x = find(subsets, next.src);

int y = find(subsets, next.dest);

if (x != y) {

result[e++] = next;

Union(subsets, x, y);

}

}

// Print the MST edges

printf("\nKruskal's MST Edges:\n");

for (i = 0; i < e; i++)

printf("%c - %c (Weight %d)\n", result[i].src + 'A', result[i].dest + 'A', result[i].weight);

}

int main() {

// Adjacency matrix for Prim's Algorithm

int graph[V][V] = {

{0, 1, 4, INF}, // A

{1, 0, 2, 3}, // B

{4, 2, 0, 5}, // C

{INF, 3, 5, 0} // D

};

// Edge list for Kruskal's Algorithm

struct Edge edges[] = {

{0, 1, 1}, {0, 2, 4}, {1, 2, 2}, {2, 3, 5}, {1, 3, 3}

};

int E = sizeof(edges) / sizeof(edges[0]);

// Calling Prim's and Kruskal's MST functions

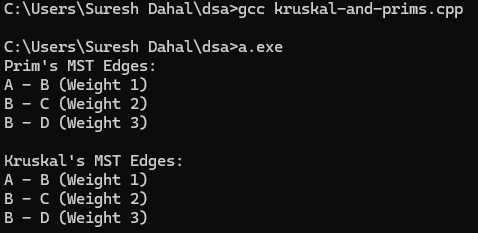
primMST(graph);

kruskalMST(edges, E);

return 0;

}

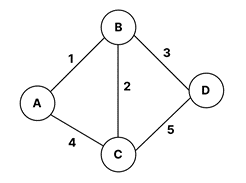
**Output:**



**Shortest Path Algorithm: Dijkstra’s Algorithm Algorithm:**

1. **Step 1**: Initialize a distance array dist[] where dist[i] represents the shortest distance from the source to vertex i. Set dist[source] = 0 and all others to infinity (INF).
2. **Step 2**: Use a priority queue (min-heap) to track unvisited nodes, starting with the source.
3. **Step 3**: While the queue is not empty:
   * Extract the node u with the smallest tentative distance.
   * For each adjacent node v, if dist[u] + weight(u, v) < dist[v], update dist[v] and add v to the queue.
4. **Step 4**: Repeat until all nodes are visited.

**Example:**



**Shortest Paths from Source A (vertex 0):**

• A to A: 0

• A to B: A → B (Distance = 1)

• A to C: A → B → C (Distance = 3)

• A to D: A → B → D (Distance = 4)

**Program:**

#include <stdio.h>

#include <limits.h>

#define V 4

// Function to find the vertex with the minimum distance value

int minDistance(int dist[], int sptSet[]) {

int min = INT\_MAX, min\_index;

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

if (sptSet[v] == 0 && dist[v] <= min) {

min = dist[v];

min\_index = v;

}

}

return min\_index;

}

// Function to implement Dijkstra's algorithm

void dijkstra(int graph[V][V], int src) {

int dist[V]; // The output array dist[i] holds the shortest distance from src to i

int sptSet[V]; // sptSet[i] will be 1 if vertex i is included in the shortest path tree

// Initialize all distances as INFINITE and sptSet[] as 0

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

dist[i] = INT\_MAX;

sptSet[i] = 0;

}

// Distance from source to itself is always 0

dist[src] = 0;

// Find the shortest path for all vertices

for (int count = 0; count < V - 1; count++) {

// Pick the minimum distance vertex from the set of vertices not yet processed

int u = minDistance(dist, sptSet);

sptSet[u] = 1; // Mark the picked vertex as processed

// Update dist[] values for the adjacent vertices of the picked vertex

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

// Update dist[v] if and only if the current vertex is not in sptSet,

// there is an edge from u to v, and the total distance through u is smaller than the current value of dist[v]

if (!sptSet[v] && graph[u][v] && dist[u] != INT\_MAX && dist[u] + graph[u][v] < dist[v]) {

dist[v] = dist[u] + graph[u][v];

}

}

}

// Print the calculated shortest distances

printf("Shortest Paths from Source A (vertex 0):\n");

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

printf("• A to ");

if (i == 0) printf("A: 0\n");

else if (i == 1) printf("B: A → B (Distance = %d)\n", dist[i]);

else if (i == 2) printf("C: A → B → C (Distance = %d)\n", dist[i]);

else if (i == 3) printf("D: A → B → D (Distance = %d)\n", dist[i]);

}

}

int main() {

// Graph representation (adjacency matrix)

int graph[V][V] = {

{0, 1, 4, 0},

{1, 0, 2, 3},

{4, 2, 0, 5},

{0, 3, 5, 0}

};

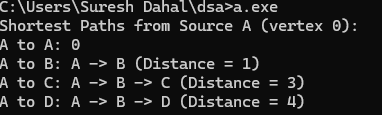
// Run Dijkstra's algorithm for source vertex 0 (A)

dijkstra(graph, 0);

return 0;

}

**Output:**



**9. Write programs for linked list implementation of stack and queue.**

**Stack using Linked List**

**Algorithm**

**Push Operation**

PUSH(Stack, VALUE)

Create a new node, NEWNODE

NEWNODE → DATA ← VALUE

NEWNODE → NEXT ← TOP

TOP ← NEWNODE

PRINT "Pushed VALUE into stack"

**POP Operation:**

POP(Stack)

IF TOP == NULL THEN

PRINT "Stack Underflow! Cannot pop"

RETURN

TEMP ← TOP

TOP ← TOP → NEXT

PRINT "Popped TEMP → DATA from stack"

DELETE TEMP

**Example**

• Push 5 → Stack: 5

• Push 15 → Stack: 15 → 5

• Push 25→ Stack: 25→ 15 → 5

• Pop → Returns 25, Stack: 15 → 5

• Pop → Returns 15, Stack: 5

**Program**

#include <stdio.h>

#include <stdlib.h>

typedef struct Node {

int value;

struct Node\* next;

} Node;

typedef struct Stack {

Node\* top;

} Stack;

Stack\* createStack() {

Stack\* stack = (Stack\*)malloc(sizeof(Stack));

stack->top = NULL;

return stack;

}

int isEmpty(Stack\* stack) {

return stack->top == NULL;

}

void push(Stack\* stack, int value) {

Node\* newNode = (Node\*)malloc(sizeof(Node));

newNode->value = value;

newNode->next = stack->top;

stack->top = newNode;

printf("Pushed: %d\n", value);

}

int pop(Stack\* stack) {

if (isEmpty(stack)) {

printf("Stack is empty. Cannot pop.\n");

return -1;

}

int value = stack->top->value;

Node\* temp = stack->top;

stack->top = stack->top->next;

free(temp);

return value;

}

int peek(Stack\* stack) {

if (isEmpty(stack)) {

printf("Stack is empty.\n");

return -1;

}

return stack->top->value;

}

void display(Stack\* stack) {

Node\* current = stack->top;

if (current == NULL) {

printf("Stack is empty.\n");

return;

}

printf("Stack elements: ");

while (current) {

printf("%d ", current->value);

current = current->next;

}

printf("\n");

}

int main() {

Stack\* stack = createStack();

push(stack, 10);

push(stack, 20);

push(stack, 30);

display(stack);

printf("Popped: %d\n", pop(stack));

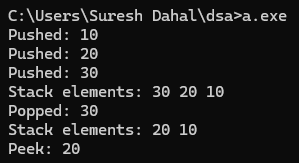
display(stack);

printf("Peek: %d\n", peek(stack));

return 0;

}

**Output**

****

**Queue Using Linked List:**

**Algorithm**

#### **Enqueue Operation**

**ENQUEUE(Queue, VALUE)**

1. Create a new node, NEWNODE
2. NEWNODE → DATA ← VALUE
3. NEWNODE → NEXT ← NULL
4. IF FRONT == NULL THEN  
        FRONT ← REAR ← NEWNODE
5. ELSE  
        REAR → NEXT ← NEWNODE  
        REAR ← NEWNODE
6. PRINT "Enqueued VALUE into queue"

#### **Dequeue Operation**

**DEQUEUE(Queue)**

1. IF FRONT == NULL THEN  
        PRINT "Queue is empty"  
        RETURN
2. SET TEMP ← FRONT
3. SET FRONT ← FRONT → NEXT
4. IF FRONT == NULL THEN  
        SET REAR ← NULL
5. PRINT "Dequeued TEMP → DATA from queue"
6. DELETE TEMP

**Example**

ENQUEUE (7)

ENQUEUE (14)

ENQUEUE (21)

DEQUEUE ()

ENQUEUE (28)

DISPLAY ()

**Program**

#include <stdio.h>

#include <stdlib.h>

struct Node {

int data;

struct Node\* next;

};

struct Node\* front = NULL;

struct Node\* rear = NULL;

void enqueue(int value) {

struct Node\* newNode = (struct Node\*)malloc(sizeof(struct Node));

newNode->data = value;

newNode->next = NULL;

if (rear == NULL) {

front = rear = newNode;

} else {

rear->next = newNode;

rear = newNode;

}

printf("Enqueued %d into queue\n", value);

}

void dequeue() {

if (front == NULL) {

printf("Queue Underflow! Cannot dequeue\n");

return;

}

struct Node\* temp = front;

printf("Dequeued %d from queue\n", temp->data);

front = front->next;

free(temp);

if (front == NULL) {

rear = NULL;

}

}

void display() {

if (front == NULL) {

printf("Queue is empty\n");

return;

}

struct Node\* ptr = front;

printf("Queue elements: ");

while (ptr) {

printf("%d ", ptr->data);

ptr = ptr->next;

}

printf("\n");

}

int main() {

enqueue(7);

enqueue(14);

enqueue(21);

dequeue();

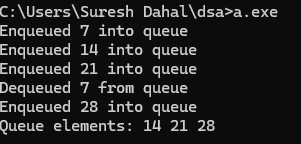
enqueue(28);

display();

return 0;

}

**Output**

****

**10. Write a program to implement basic operations on a singly linked list.**

**Algorithm:**

#### **1. Insert at the Beginning**

**INSERT\_BEGINNING(LIST, VALUE)**

1. Create a new node, NEWNODE
2. NEWNODE → DATA ← VALUE
3. NEWNODE → NEXT ← HEAD
4. HEAD ← NEWNODE
5. PRINT "Inserted VALUE at the beginning"

#### **2. Insert at the End**

**INSERT\_END(LIST, VALUE)**

1. Create a new node, NEWNODE
2. NEWNODE → DATA ← VALUE
3. NEWNODE → NEXT ← NULL
4. IF HEAD == NULL THEN  
        HEAD ← NEWNODE
5. ELSE  
        SET TEMP ← HEAD  
        WHILE TEMP → NEXT ≠ NULL  
            TEMP ← TEMP → NEXT  
        TEMP → NEXT ← NEWNODE
6. PRINT "Inserted VALUE at the end"

#### **3. Insert at a Specific Position**

**INSERT\_AT\_POSITION(LIST, VALUE, POSITION)**

1. Create a new node, NEWNODE
2. NEWNODE → DATA ← VALUE
3. IF POSITION == 1 THEN  
        NEWNODE → NEXT ← HEAD  
        HEAD ← NEWNODE  
        RETURN
4. SET TEMP ← HEAD, COUNT ← 1
5. WHILE TEMP ≠ NULL AND COUNT < POSITION - 1  
        TEMP ← TEMP → NEXT  
        COUNT ← COUNT + 1
6. IF TEMP == NULL THEN  
        PRINT "Invalid Position"  
        RETURN
7. NEWNODE → NEXT ← TEMP → NEXT
8. TEMP → NEXT ← NEWNODE
9. PRINT "Inserted VALUE at position POSITION"

#### **4. Delete a Node by Value**

**DELETE\_NODE(LIST, VALUE)**

1. IF HEAD == NULL THEN  
        PRINT "List is empty"  
        RETURN
2. IF HEAD → DATA == VALUE THEN  
        SET TEMP ← HEAD  
        HEAD ← HEAD → NEXT  
        DELETE TEMP  
        PRINT "Deleted VALUE"  
        RETURN
3. SET TEMP ← HEAD
4. WHILE TEMP → NEXT ≠ NULL AND TEMP → NEXT → DATA ≠ VALUE  
        TEMP ← TEMP → NEXT
5. IF TEMP → NEXT == NULL THEN  
        PRINT "Value not found"  
        RETURN
6. SET NODE\_TO\_DELETE ← TEMP → NEXT
7. TEMP → NEXT ← TEMP → NEXT → NEXT
8. DELETE NODE\_TO\_DELETE
9. PRINT "Deleted VALUE"

#### **5. Delete at a Specific Position**

**DELETE\_AT\_POSITION(LIST, POSITION)**

1. IF HEAD == NULL THEN  
        PRINT "List is empty"  
        RETURN
2. IF POSITION == 1 THEN  
        SET TEMP ← HEAD  
        HEAD ← HEAD → NEXT  
        DELETE TEMP  
        PRINT "Deleted node at position POSITION"  
        RETURN
3. SET TEMP ← HEAD, COUNT ← 1
4. WHILE TEMP ≠ NULL AND COUNT < POSITION - 1  
        TEMP ← TEMP → NEXT  
        COUNT ← COUNT + 1
5. IF TEMP == NULL OR TEMP → NEXT == NULL THEN  
        PRINT "Invalid Position"  
        RETURN
6. SET NODE\_TO\_DELETE ← TEMP → NEXT
7. TEMP → NEXT ← TEMP → NEXT → NEXT
8. DELETE NODE\_TO\_DELETE
9. PRINT "Deleted node at position POSITION"

#### **6. Search for a Value**

**SEARCH(LIST, VALUE)**

1. SET TEMP ← HEAD, POSITION ← 1
2. WHILE TEMP ≠ NULL  
        IF TEMP → DATA == VALUE THEN  
            PRINT "Value found at position POSITION"  
            RETURN  
        TEMP ← TEMP → NEXT  
        POSITION ← POSITION + 1
3. PRINT "Value not found"

#### **7. Display the List**

**DISPLAY(LIST)**

1. IF HEAD == NULL THEN  
        PRINT "List is empty"  
        RETURN
2. SET TEMP ← HEAD
3. WHILE TEMP ≠ NULL  
        PRINT TEMP → DATA  
        TEMP ← TEMP → NEXT

**Example**

1️. **Insert at Beginning**

* **Insert(10)** → List: 10
* **Insert(20)** → List: 20 → 10
* **Insert(30)** → List: 30 → 20 → 10

2️. **Insert at End**

* **Insert at End(40)** → List: 30 → 20 → 10 → 40
* **Insert at End(50)** → List: 30 → 20 → 10 → 40 → 50

3️. **Insert at Position**

* **Insert(25) at position 3** → List: 30 → 20 → 25 → 10 → 40 → 50

4️. **Delete by Value**

* **Delete(10)** → List: 30 → 20 → 25 → 40 → 50
* **Delete(30)** → List: 20 → 25 → 40 → 50

5️. **Delete at Position**

* **Delete at position 2** → List: 20 → 40 → 50

6️. **Search for Value**

* **Search(40)** → "Found at position 2"
* **Search(100)** → "Not found"

7️. **Final List Display**

* **List:** 20 → 40 → 50

**Program**

#include <stdio.h>

#include <stdlib.h>

struct Node {

int data;

struct Node\* next;

};

// Global Head Pointer

struct Node\* head = NULL;

void insertAtBeginning(int value) {

struct Node\* newNode = (struct Node\*)malloc(sizeof(struct Node));

newNode->data = value;

newNode->next = head;

head = newNode;

}

void insertAtEnd(int value) {

struct Node\* newNode = (struct Node\*)malloc(sizeof(struct Node));

newNode->data = value;

newNode->next = NULL;

if (head == NULL) {

head = newNode;

return;

}

struct Node\* temp = head;

while (temp->next != NULL) {

temp = temp->next;

}

temp->next = newNode;

}

void insertAtPosition(int value, int position) {

struct Node\* newNode = (struct Node\*)malloc(sizeof(struct Node));

newNode->data = value;

if (position == 1) {

newNode->next = head;

head = newNode;

return;

}

struct Node\* temp = head;

for (int i = 1; temp != NULL && i < position - 1; i++) {

temp = temp->next;

}

if (temp == NULL) {

printf("Invalid Position!\n");

free(newNode);

return;

}

newNode->next = temp->next;

temp->next = newNode;

}

void deleteByValue(int value) {

struct Node\* temp = head, \*prev = NULL;

if (temp != NULL && temp->data == value) {

head = temp->next;

free(temp);

return;

}

while (temp != NULL && temp->data != value) {

prev = temp;

temp = temp->next;

}

if (temp == NULL) {

printf("Value not found!\n");

return;

}

prev->next = temp->next;

free(temp);

}

void deleteAtPosition(int position) {

if (head == NULL) {

printf("List is empty!\n");

return;

}

struct Node\* temp = head;

if (position == 1) {

head = head->next;

free(temp);

return;

}

struct Node\* prev = NULL;

for (int i = 1; temp != NULL && i < position; i++) {

prev = temp;

temp = temp->next;

}

if (temp == NULL) {

printf("Invalid Position!\n");

return;

}

prev->next = temp->next;

free(temp);

}

void search(int value) {

struct Node\* temp = head;

int position = 1;

while (temp != NULL) {

if (temp->data == value) {

printf("Value %d found at position %d\n", value, position);

return;

}

temp = temp->next;

position++;

}

printf("Value %d not found!\n", value);

}

void display() {

struct Node\* temp = head;

if (temp == NULL) {

printf("List is empty!\n");

return;

}

printf("List: ");

while (temp != NULL) {

printf("%d -> ", temp->data);

temp = temp->next;

}

printf("NULL\n");

}

int main() {

printf("Performing Insertions...\n");

insertAtBeginning(10);

insertAtBeginning(20);

insertAtBeginning(30);

display();

insertAtEnd(40);

insertAtEnd(50);

display();

insertAtPosition(25, 3);

display();

printf("\nPerforming Deletions...\n");

deleteByValue(10);

deleteByValue(30);

display();

deleteAtPosition(2);

display();

printf("\nPerforming Searches...\n");

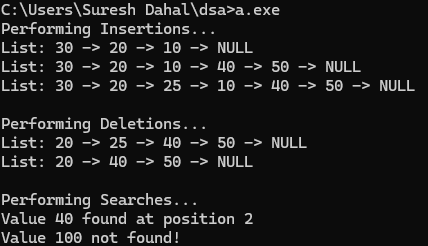
search(40);

search(100);

return 0;

}

**Output**

****