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>
```

```c
// 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:

```
C:\Users\Suresh Dahal\dsa>a.exe
Inorder after insertion: 20 30 40 50 60 70 80
Inorder after deletions: 40 60 70 80
C:\Users\Suresh Dahal\dsa>
```

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:

```
C:\Users\Suresh Dahal\dsa>a.exe
Original array: 4 2 0 1 3
Sorted array: 0 1 2 3 4
```

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;
}
```

<u>Output:</u>

```
C:\Users\Suresh Dahal\dsa>a.exe
Original array: 4 2 0 1 3
Sorted array: 0 1 2 3 4
```

Selection Sort

<u>Algorithm:</u>

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:

```
C:\Users\Suresh Dahal\dsa>a.exe
Original array: 4 2 0 1 3
Sorted array: 0 1 2 3 4
```

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:

```
C:\Users\Suresh Dahal\dsa>a.exe
Original array: 4 2 0 1 3
Sorted array: 0 1 2 3 4
```

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:

```
C:\Users\Suresh Dahal\dsa>a.exe
Original array: 4 2 0 1 3
Sorted array: 0 1 2 3 4
```

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:

```
C:\Users\Suresh Dahal\dsa>a.exe
Enter the target value: 3
Element found at index 3
```

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:

```
C:\Users\Suresh Dahal\dsa>a.exe
Enter the target value: 3
Element found at index 4
```

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:

```
     0
    / \
   1   2
  / \   \
 3   4   5
```

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:

```
C:\Users\Suresh Dahal\dsa>a.exe
BFS Traversal: 0 1 2 3 4 5
DFS Traversal: 0 1 3 4 2 5
```

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.

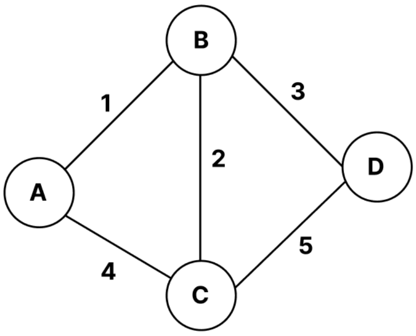
B. Kruskal's Algorithm:

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:

```
C:\Users\Suresh Dahal\dsa>gcc kruskal-and-prims.cpp

C:\Users\Suresh Dahal\dsa>a.exe
Prim's MST Edges:
A - B (Weight 1)
B - C (Weight 2)
B - D (Weight 3)

Kruskal's MST Edges:
A - B (Weight 1)
B - C (Weight 2)
B - D (Weight 3)
```

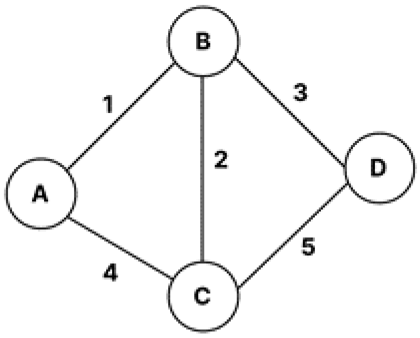
Shortest Path Algorithm: Dijkstra’s Algorithm

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:

```
C:\Users\Suresh Dahal\dsa>a.exe
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)
```

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;
}
```

<u>Output</u>

```
C:\Users\Suresh Dahal\dsa>a.exe
Pushed: 10
Pushed: 20
Pushed: 30
Stack elements: 30 20 10
Popped: 30
Stack elements: 20 10
Peek: 20
```

Queue Using Linked List:

<u>Algorithm</u>

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

```
C:\Users\Suresh Dahal\dsa>a.exe
Enqueued 7 into queue
Enqueued 14 into queue
Enqueued 21 into queue
Dequeued 7 from queue
Enqueued 28 into queue
Queue elements: 14 21 28
```

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

1. **Insert at Beginning**

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

2. **Insert at End**

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

3. **Insert at Position**

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

4. **Delete by Value**

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

5. **Delete at Position**

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

6. **Search for Value**

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

7. **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;
}
```

```c
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);
```

```c
    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

```
C:\Users\Suresh Dahal\dsa>a.exe
Performing Insertions...
List: 30 -> 20 -> 10 -> NULL
List: 30 -> 20 -> 10 -> 40 -> 50 -> NULL
List: 30 -> 20 -> 25 -> 10 -> 40 -> 50 -> NULL

Performing Deletions...
List: 20 -> 25 -> 40 -> 50 -> NULL
List: 20 -> 40 -> 50 -> NULL

Performing Searches...
Value 40 found at position 2
Value 100 not found!
```