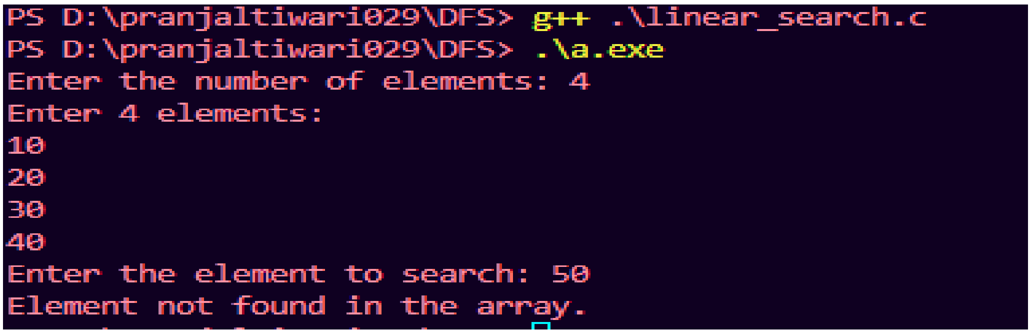
Q1) Write a program in C to implement Linear Search

Code

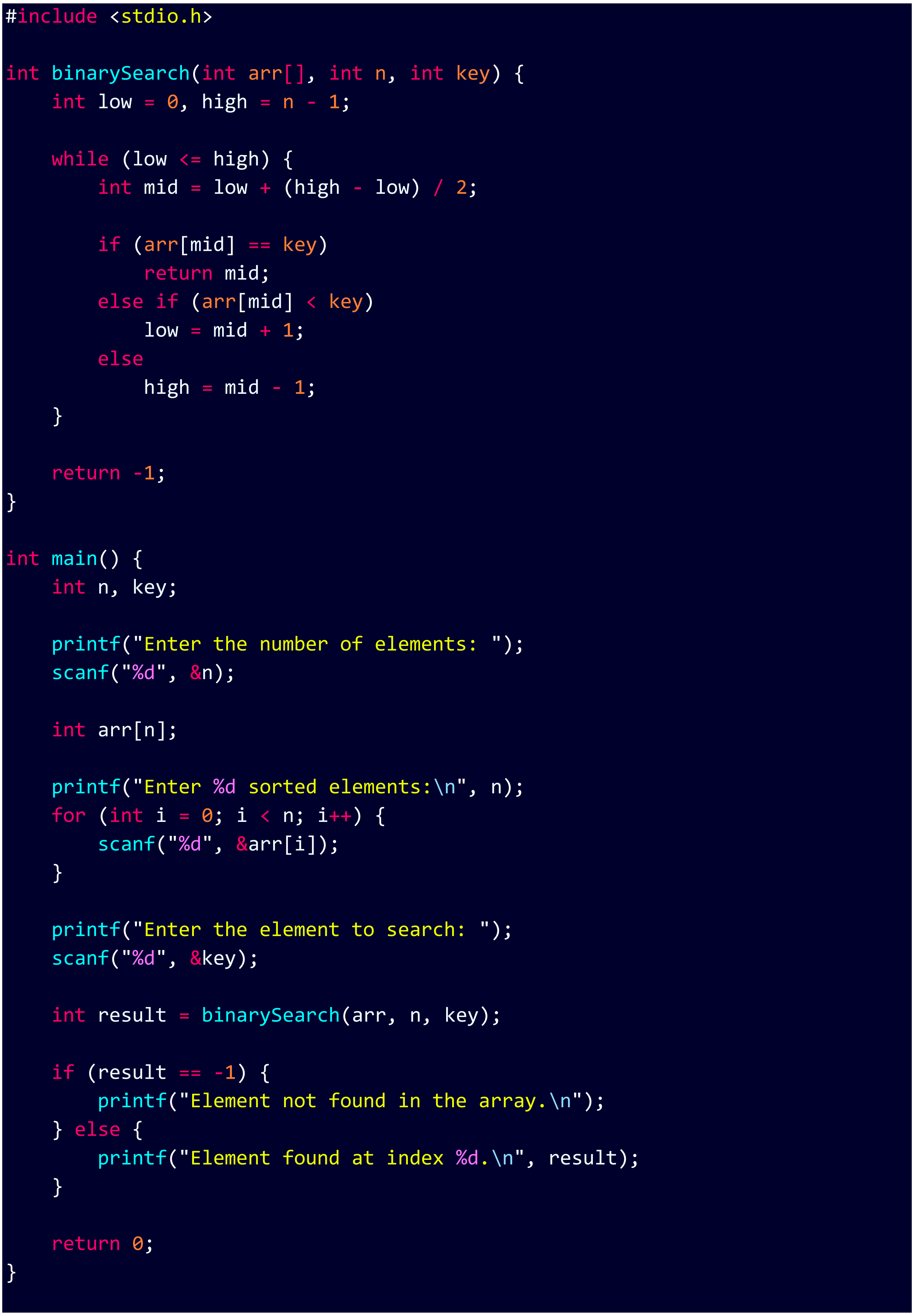
```c
#include <stdio.h>

int linearSearch(int arr[], int n, int key) {
    for (int i = 0; i < n; i++) {
        if (arr[i] == key) {
            return i;
        }
    }
    return -1;
}
int main() {
    int n, key;

    printf("Enter the number of elements: ");
    scanf("%d", &n);

    int arr[n];

    printf("Enter %d elements:\n", n);
    for (int i = 0; i < n; i++) {
        scanf("%d", &arr[i]);
    }
    printf("Enter the element to search: ");
    scanf("%d", &key);

    int result = linearSearch(arr, n, key);

    if (result == -1) {
        printf("Element not found in the array.\n");
    } else {
        printf("Element found at index %d.\n", result);
    }
    return 0;
}
```

Output



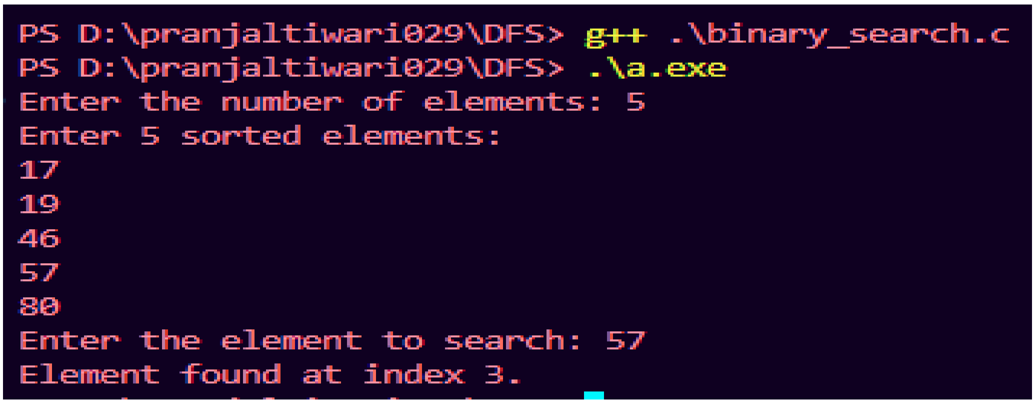
```
PS D:\pranjaltiwari029\DFS> g++ .\linear_search.c
PS D:\pranjaltiwari029\DFS> .\a.exe
Enter the number of elements: 4
Enter 4 elements:
10
20
30
40
Enter the element to search: 50
Element not found in the array.
```

Q2) Write a program in C to implement Binary Search



```c
#include <stdio.h>

int binarySearch(int arr[], int n, int key) {
    int low = 0, high = n - 1;

    while (low <= high) {
        int mid = low + (high - low) / 2;

        if (arr[mid] == key)
            return mid;
        else if (arr[mid] < key)
            low = mid + 1;
        else
            high = mid - 1;
    }

    return -1;
}

int main() {
    int n, key;

    printf("Enter the number of elements: ");
    scanf("%d", &n);

    int arr[n];

    printf("Enter %d sorted elements:\n", n);
    for (int i = 0; i < n; i++) {
        scanf("%d", &arr[i]);
    }

    printf("Enter the element to search: ");
    scanf("%d", &key);

    int result = binarySearch(arr, n, key);

    if (result == -1) {
        printf("Element not found in the array.\n");
    } else {
        printf("Element found at index %d.\n", result);
    }

    return 0;
}
```

OUTPUT



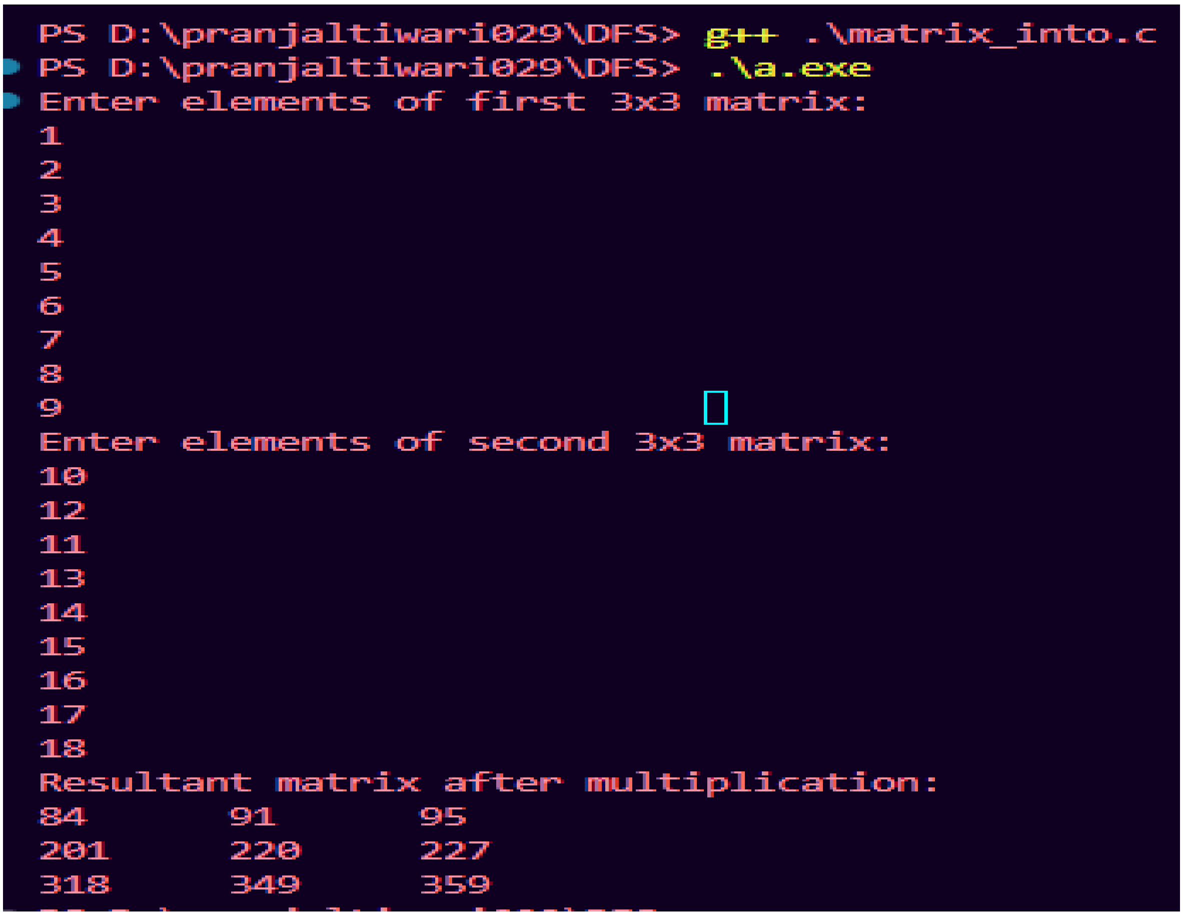
```
PS D:\pranjaltiwari029\DFS> g++ .\binary_search.c
PS D:\pranjaltiwari029\DFS> .\a.exe
Enter the number of elements: 5
Enter 5 sorted elements:
17
19
46
57
80
Enter the element to search: 57
Element found at index 3.
```

Q3) Write a program in C to implement Matrix Multiplication on two Matrices of 3x3.

Code

```c
#include <stdio.h>

int main() {
    int a[3][3], b[3][3], result[3][3];
    int i, j, k;


    printf("Enter elements of first 3x3 matrix:\n");
    for (i = 0; i < 3; i++) {
        for (j = 0; j < 3; j++) {
            scanf("%d", &a[i][j]);
        }
    }


    printf("Enter elements of second 3x3 matrix:\n");
    for (i = 0; i < 3; i++) {
        for (j = 0; j < 3; j++) {
            scanf("%d", &b[i][j]);
        }
    }


    for (i = 0; i < 3; i++) {
        for (j = 0; j < 3; j++) {
            result[i][j] = 0;
        }
    }


    for (i = 0; i < 3; i++) {
        for (j = 0; j < 3; j++) {
            for (k = 0; k < 3; k++) {
                result[i][j] += a[i][k] * b[k][j];
            }
        }
    }


    printf("Resultant matrix after multiplication:\n");
    for (i = 0; i < 3; i++) {
        for (j = 0; j < 3; j++) {
            printf("%d\t", result[i][j]);
        }
        printf("\n");
    }

    return 0;
}
```

OUTPUT



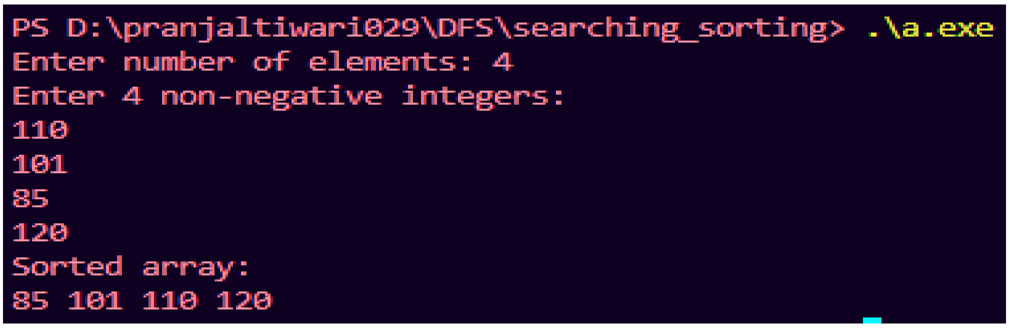
```
PS D:\pranjaltiwari029\DFS> g++ .\matrix_into.c
PS D:\pranjaltiwari029\DFS> .\a.exe
Enter elements of first 3x3 matrix:
1
2
3
4
5
6
7
8
9
Enter elements of second 3x3 matrix:
10
12
11
13
14
15
16
17
18
Resultant matrix after multiplication:
84      91      95
201     220     227
318     349     359
```

Q4) Write a program in C to implement Selection Sort

Code

```
#include <stdio.h>

void selectionSort(int arr[], int n) {
    int i, j, min_idx, temp;

    for (i = 0; i < n-1; i++) {
        min_idx = i; // Assume the current element is the minimum

        // Find the index of the minimum element in the remaining array
        for (j = i+1; j < n; j++) {
            if (arr[j] < arr[min_idx]) {
                min_idx = j;
            }
        }

        // Swap the found minimum element with the first element
        temp = arr[min_idx];
        arr[min_idx] = arr[i];
        arr[i] = temp;
    }
}

int main() {
    int n, i;

    printf("Enter number of elements: ");
    scanf("%d", &n);

    int arr[n];

    printf("Enter %d elements:\n", n);
    for (i = 0; i < n; i++) {
        scanf("%d", &arr[i]);
    }

    selectionSort(arr, n);

    printf("Sorted array:\n");
    for (i = 0; i < n; i++) {
        printf("%d ", arr[i]);
    }
    printf("\n");

    return 0;
}
```

OUTPUT

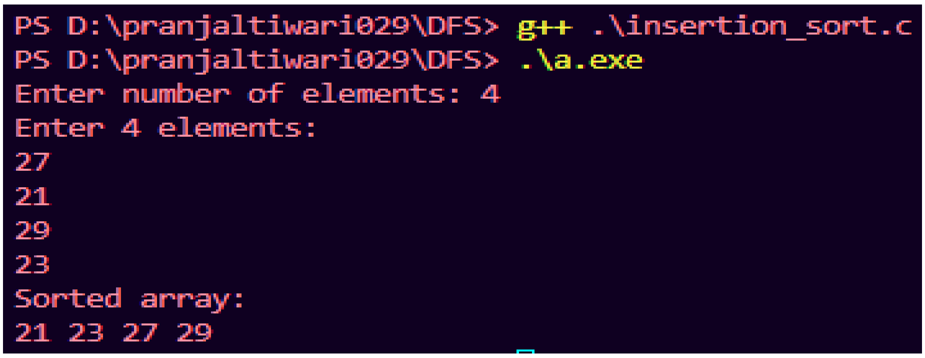


```
PS D:\pranjaltiwari029\DFS\searching_sorting> .\a.exe
Enter number of elements: 4
Enter 4 non-negative integers:
110
101
85
120
Sorted array:
85 101 110 120
```

Q5) Write a program in C to implement insertion sort

```c
#include <stdio.h>

void insertionSort(int arr[], int n) {
    int i, key, j;

    for (i = 1; i < n; i++) {
        key = arr[i]; // current element to be inserted
        j = i - 1;

        // Move elements of arr[0..i-1] that are greater than key
        // to one position ahead of their current position
        while (j >= 0 && arr[j] > key) {
            arr[j + 1] = arr[j];
            j = j - 1;
        }

        arr[j + 1] = key; // Insert the key at correct position
    }
}

int main() {
    int n, i;

    printf("Enter number of elements: ");
    scanf("%d", &n);

    int arr[n];

    printf("Enter %d elements:\n", n);
    for (i = 0; i < n; i++) {
        scanf("%d", &arr[i]);
    }

    insertionSort(arr, n);

    printf("Sorted array:\n");
    for (i = 0; i < n; i++) {
        printf("%d ", arr[i]);
    }
    printf("\n");

    return 0;
}
```

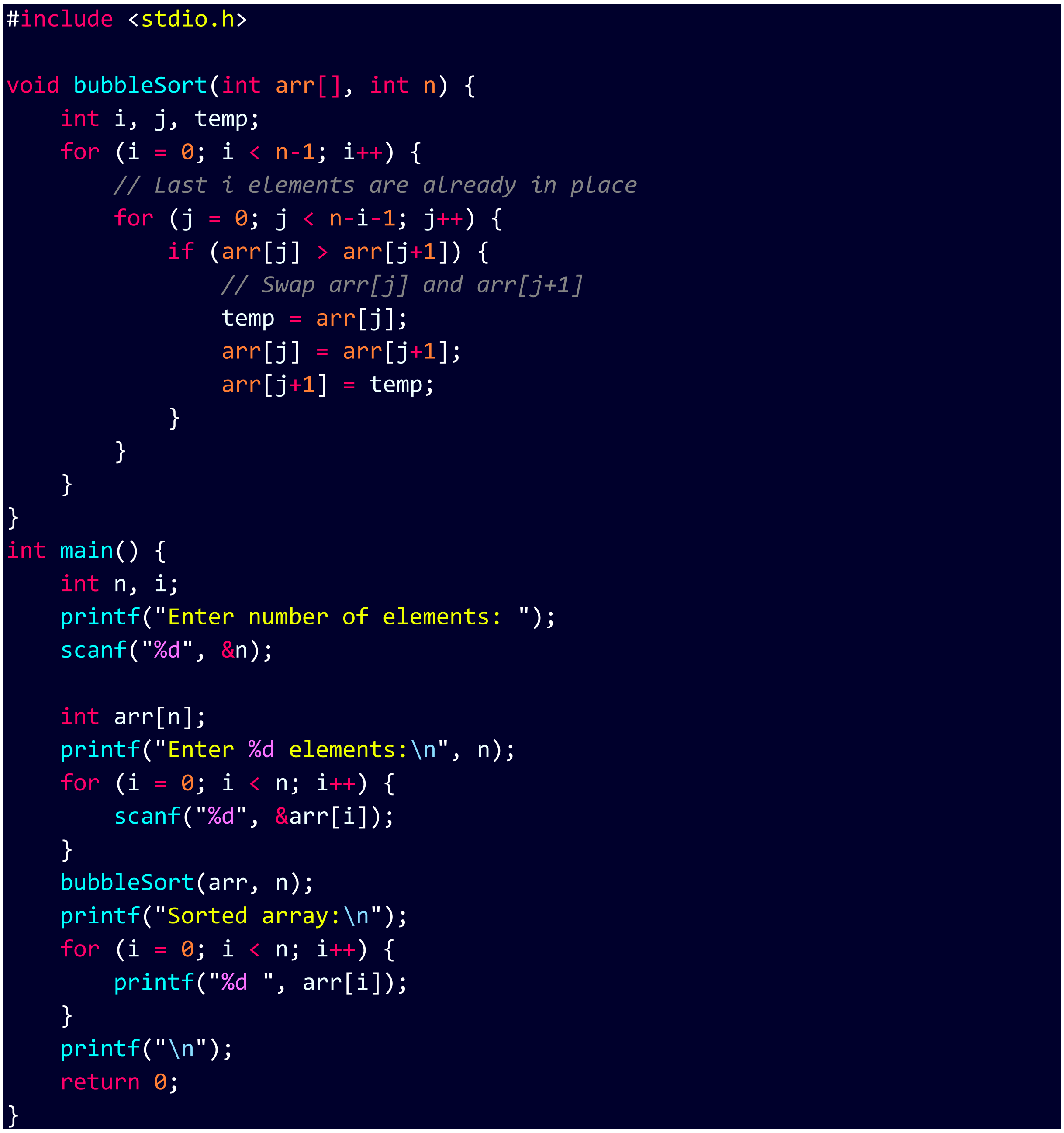
OUTPUT



```
PS D:\pranjaltiwari029\DFS> g++ .\insertion_sort.c
PS D:\pranjaltiwari029\DFS> .\a.exe
Enter number of elements: 4
Enter 4 elements:
27
21
29
23
Sorted array:
21 23 27 29
```

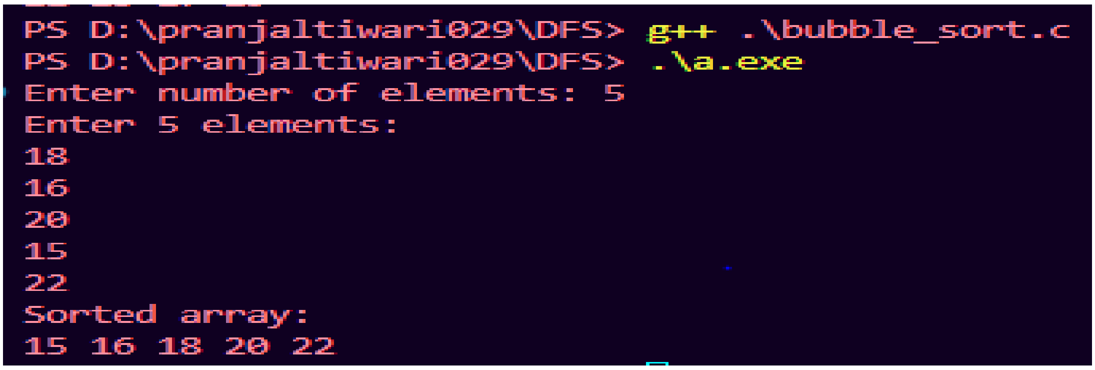
Q6) Write a program in C to implement Bubble Sort

Code



```c
#include <stdio.h>

void bubbleSort(int arr[], int n) {
    int i, j, temp;
    for (i = 0; i < n-1; i++) {
        // Last i elements are already in place
        for (j = 0; j < n-i-1; j++) {
            if (arr[j] > arr[j+1]) {
                // Swap arr[j] and arr[j+1]
                temp = arr[j];
                arr[j] = arr[j+1];
                arr[j+1] = temp;
            }
        }
    }
}
int main() {
    int n, i;
    printf("Enter number of elements: ");
    scanf("%d", &n);

    int arr[n];
    printf("Enter %d elements:\n", n);
    for (i = 0; i < n; i++) {
        scanf("%d", &arr[i]);
    }
    bubbleSort(arr, n);
    printf("Sorted array:\n");
    for (i = 0; i < n; i++) {
        printf("%d ", arr[i]);
    }
    printf("\n");
    return 0;
}
```

Output

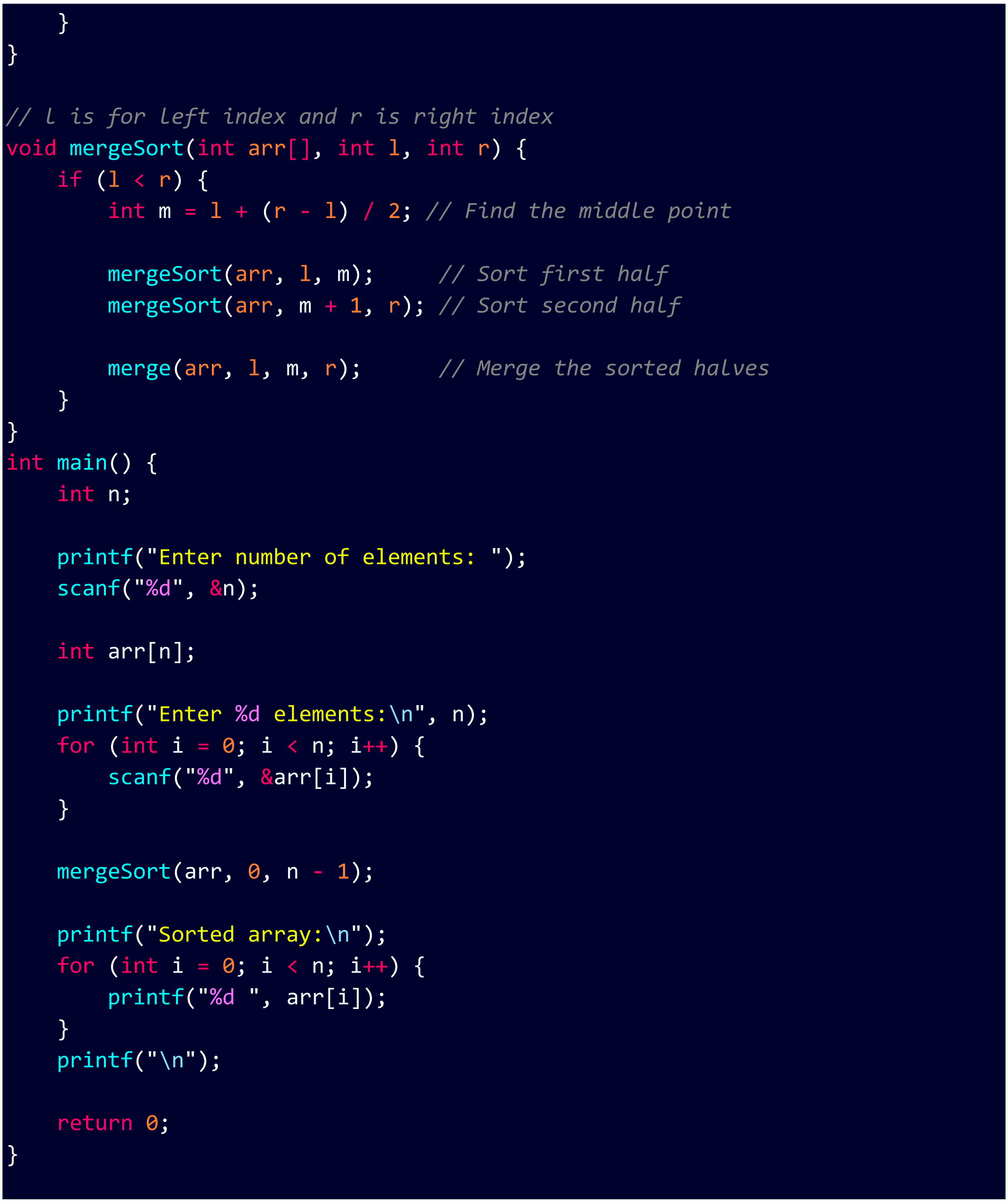


```
PS D:\pranjaltiwari029\DFS> g++ .\bubble_sort.c
PS D:\pranjaltiwari029\DFS> .\a.exe
Enter number of elements: 5
Enter 5 elements:
18
16
20
15
22
Sorted array:
15 16 18 20 22
```

Q7) Write a program in C to implement Merge Sort

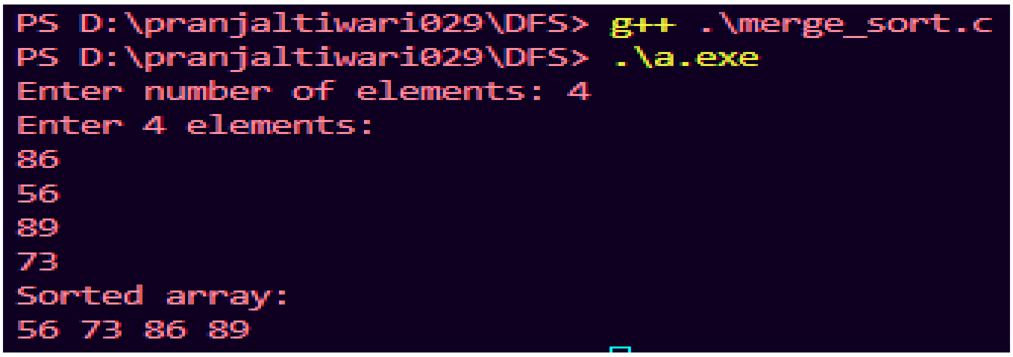
Code

```c
#include <stdio.h>

// Merge two subarrays of arr[]
void merge(int arr[], int l, int m, int r) {
    int i, j, k;
    int n1 = m - l + 1;
    int n2 = r - m;

    // Create temporary arrays
    int L[n1], R[n2];

    // Copy data to temp arrays L[] and R[]
    for (i = 0; i < n1; i++)
        L[i] = arr[l + i];
    for (j = 0; j < n2; j++)
        R[j] = arr[m + 1 + j];

    // Merge the temp arrays back into arr[l..r]
    i = 0; // Initial index of first subarray
    j = 0; // Initial index of second subarray
    k = l; // Initial index of merged subarray

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

    // Copy remaining elements of L[], if any
    while (i < n1) {
        arr[k] = L[i];
        i++;
        k++;
    }

    // Copy remaining elements of R[], if any
    while (j < n2) {
        arr[k] = R[j];
        j++;
        k++;
```



```
    }
}

// l is for left index and r is right index
void mergeSort(int arr[], int l, int r) {
    if (l < r) {
        int m = l + (r - l) / 2; // Find the middle point

        mergeSort(arr, l, m);     // Sort first half
        mergeSort(arr, m + 1, r); // Sort second half

        merge(arr, l, m, r);      // Merge the sorted halves
    }
}
int main() {
    int n;

    printf("Enter number of elements: ");
    scanf("%d", &n);

    int arr[n];

    printf("Enter %d elements:\n", n);
    for (int i = 0; i < n; i++) {
        scanf("%d", &arr[i]);
    }

    mergeSort(arr, 0, n - 1);

    printf("Sorted array:\n");
    for (int i = 0; i < n; i++) {
        printf("%d ", arr[i]);
    }
    printf("\n");

    return 0;
}
```

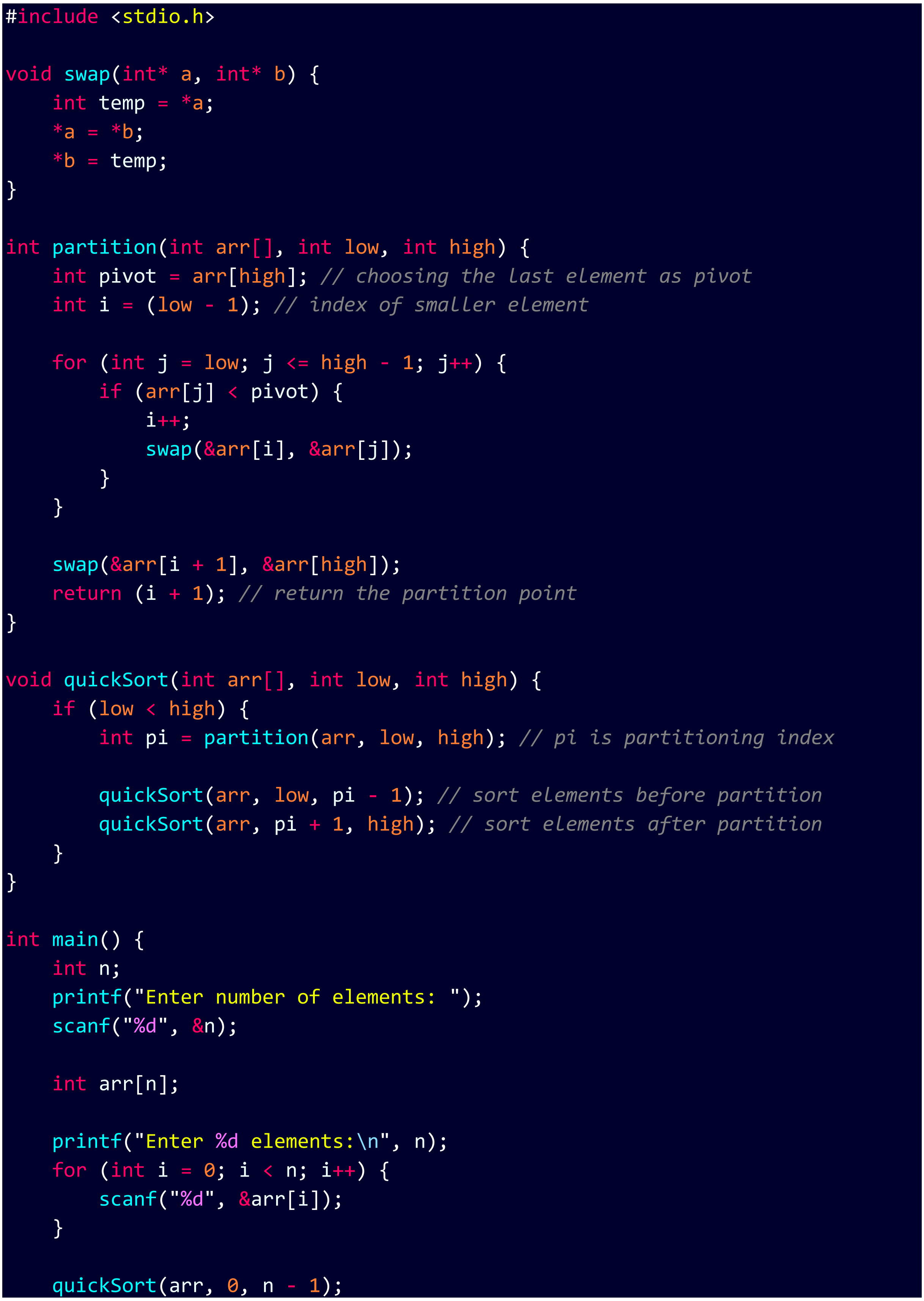
OUTPUT



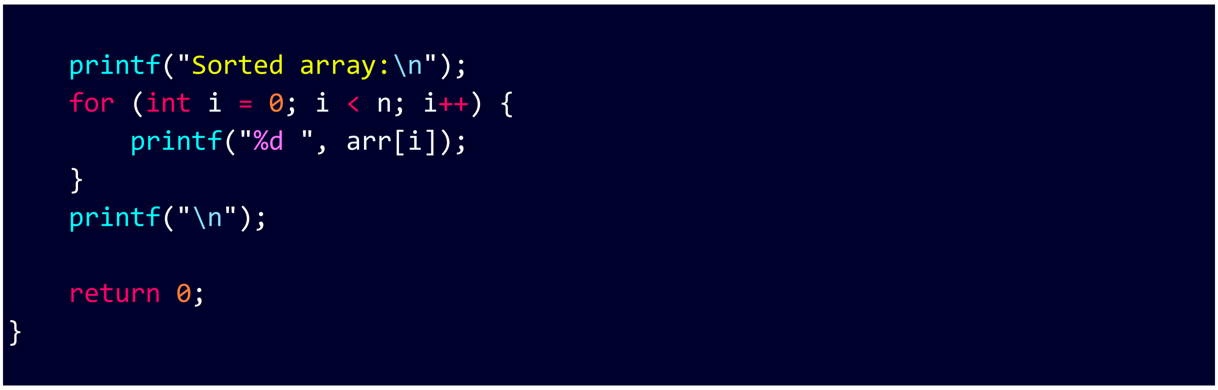
```
PS D:\pranjaltiwari029\DFS> g++ .\merge_sort.c
PS D:\pranjaltiwari029\DFS> .\a.exe
Enter number of elements: 4
Enter 4 elements:
86
56
89
73
Sorted array:
56 73 86 89
```

Q8) Write a program in C to implement quick sort

Code

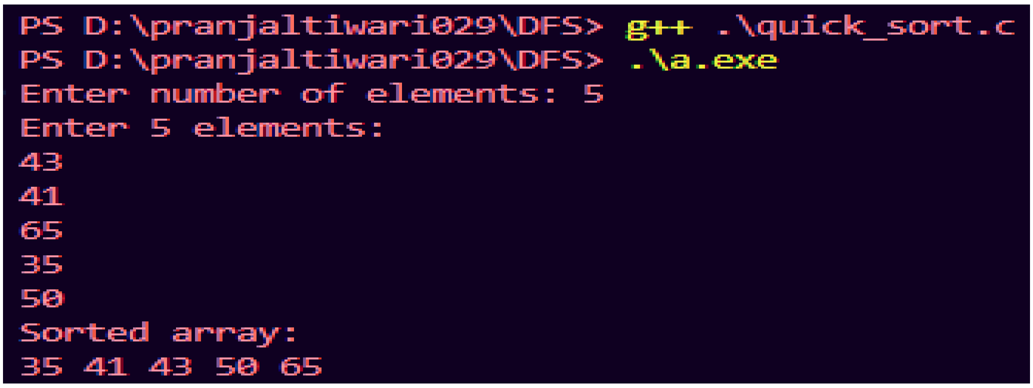


```c
#include <stdio.h>

void swap(int* a, int* b) {
    int temp = *a;
    *a = *b;
    *b = temp;
}

int partition(int arr[], int low, int high) {
    int pivot = arr[high]; // choosing the last element as pivot
    int i = (low - 1); // index of smaller element

    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); // return the partition point
}

void quickSort(int arr[], int low, int high) {
    if (low < high) {
        int pi = partition(arr, low, high); // pi is partitioning index

        quickSort(arr, low, pi - 1); // sort elements before partition
        quickSort(arr, pi + 1, high); // sort elements after partition
    }
}

int main() {
    int n;
    printf("Enter number of elements: ");
    scanf("%d", &n);

    int arr[n];

    printf("Enter %d elements:\n", n);
    for (int i = 0; i < n; i++) {
        scanf("%d", &arr[i]);
    }

    quickSort(arr, 0, n - 1);
```



```c
    printf("Sorted array:\n");
    for (int i = 0; i < n; i++) {
        printf("%d ", arr[i]);
    }
    printf("\n");

    return 0;
}
```

Output

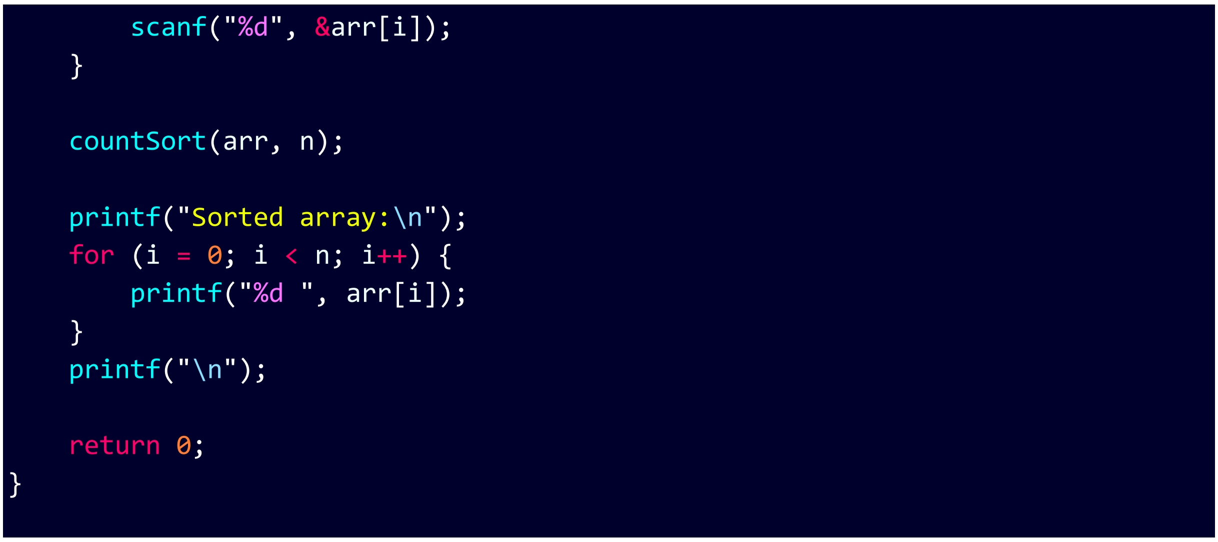


```
PS D:\pranjaltiwari029\DFS> g++ .\quick_sort.c
PS D:\pranjaltiwari029\DFS> .\a.exe
Enter number of elements: 5
Enter 5 elements:
43
41
65
35
50
Sorted array:
35 41 43 50 65
```

Q9) Write a program in C to implement Count Sort.

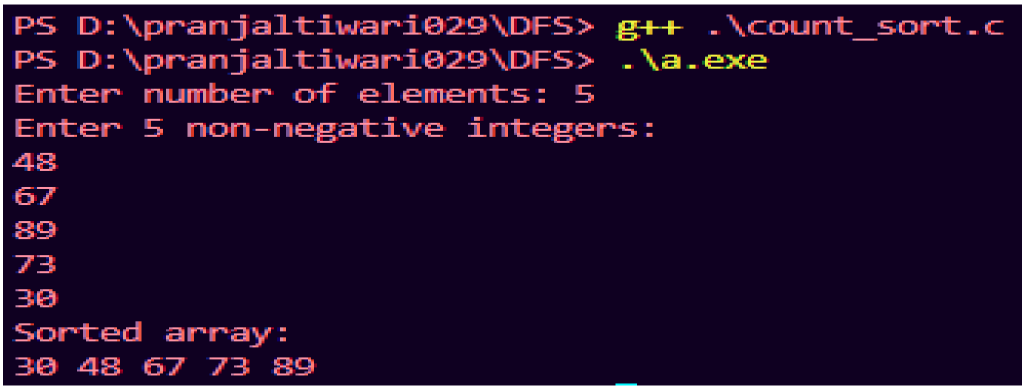
Code

```
#include <stdio.h>

void countSort(int arr[], int n) {
    int i;

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

    // Create a count array to store count of individual elements
    int count[max + 1];

    // Initialize count array with 0
    for (i = 0; i <= max; i++) {
        count[i] = 0;
    }

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

    // Modify the original array using the count array
    int index = 0;
    for (i = 0; i <= max; i++) {
        while (count[i] > 0) {
            arr[index++] = i;
            count[i]--;
        }
    }
}

int main() {
    int n, i;

    printf("Enter number of elements: ");
    scanf("%d", &n);

    int arr[n];

    printf("Enter %d non-negative integers:\n", n);
    for (i = 0; i < n; i++) {
```



```
        scanf("%d", &arr[i]);
    }

    countSort(arr, n);

    printf("Sorted array:\n");
    for (i = 0; i < n; i++) {
        printf("%d ", arr[i]);
    }
    printf("\n");

    return 0;
}
```

Output

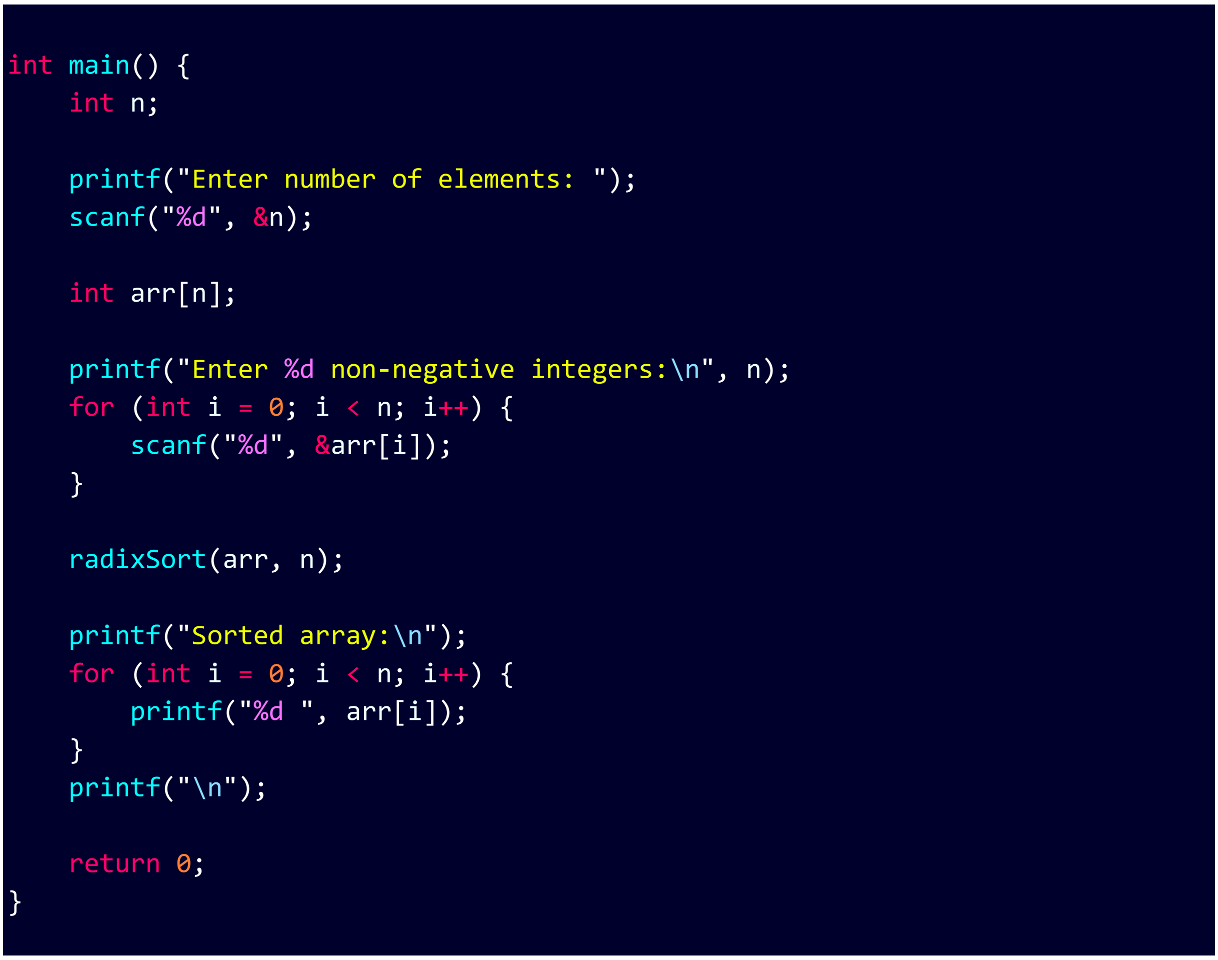


```
PS D:\pranjaltiwari029\DFS> g++ .\count_sort.c
PS D:\pranjaltiwari029\DFS> .\a.exe
Enter number of elements: 5
Enter 5 non-negative integers:
48
67
89
73
30
Sorted array:
30 48 67 73 89
```

Q10) Write a program in C to implement Radix Sort.

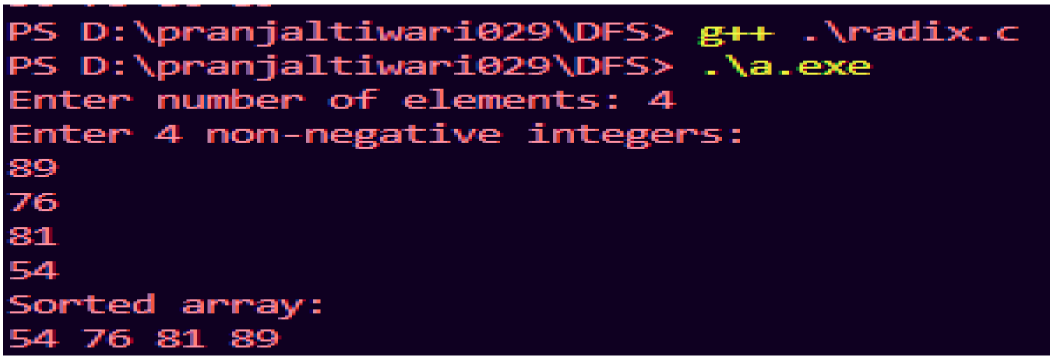
Code

```c
#include <stdio.h>

// A utility function to get the maximum value in arr[]
int getMax(int arr[], int n) {
    int max = arr[0];
    for (int i = 1; i < n; i++)
        if (arr[i] > max)
            max = arr[i];
    return max;
}

// A function to do counting sort based on a specific digit (exp is 1, 10, 100, etc.)
void countSort(int arr[], int n, int exp) {
    int output[n]; // output array
    int count[10] = {0};

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

    // Change count[i] so that it contains actual position
    for (int i = 1; i < 10; i++)
        count[i] += count[i - 1];

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

    // Copy the output array back to arr[]
    for (int i = 0; i < n; i++)
        arr[i] = output[i];
}

// The main function to that sorts arr[] using Radix Sort
void radixSort(int arr[], int n) {
    int max = getMax(arr, n);

    // Do counting sort for every digit (exp = 1, 10, 100, ...)
    for (int exp = 1; max / exp > 0; exp *= 10)
        countSort(arr, n, exp);
}
```



```
int main() {
    int n;

    printf("Enter number of elements: ");
    scanf("%d", &n);

    int arr[n];

    printf("Enter %d non-negative integers:\n", n);
    for (int i = 0; i < n; i++) {
        scanf("%d", &arr[i]);
    }

    radixSort(arr, n);

    printf("Sorted array:\n");
    for (int i = 0; i < n; i++) {
        printf("%d ", arr[i]);
    }
    printf("\n");

    return 0;
}
```

Output

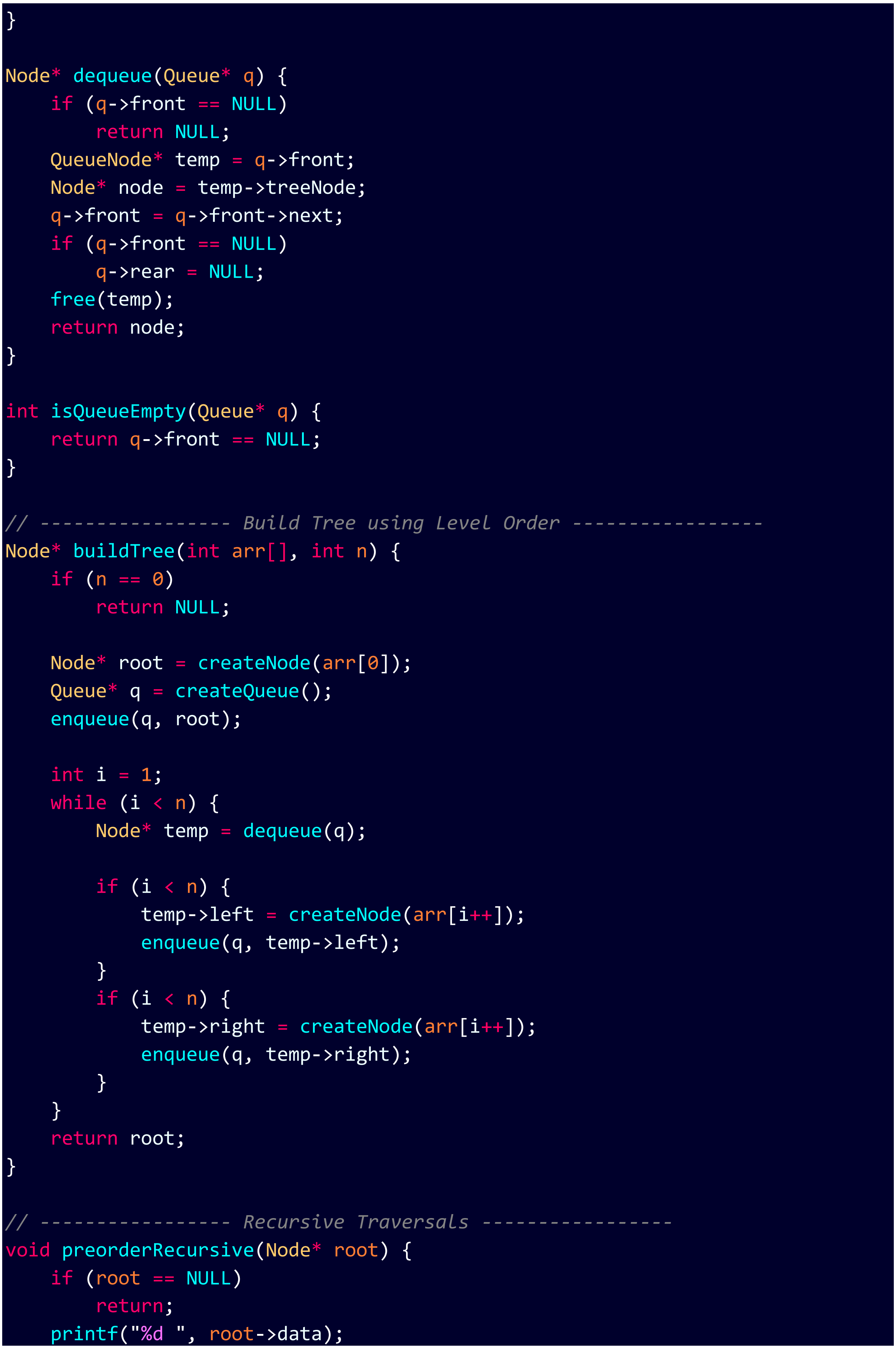


```
PS D:\pranjaltiwari029\DFS> g++ .\radix.c
PS D:\pranjaltiwari029\DFS> .\a.exe
Enter number of elements: 4
Enter 4 non-negative integers:
89
76
81
54
Sorted array:
54 76 81 89
```

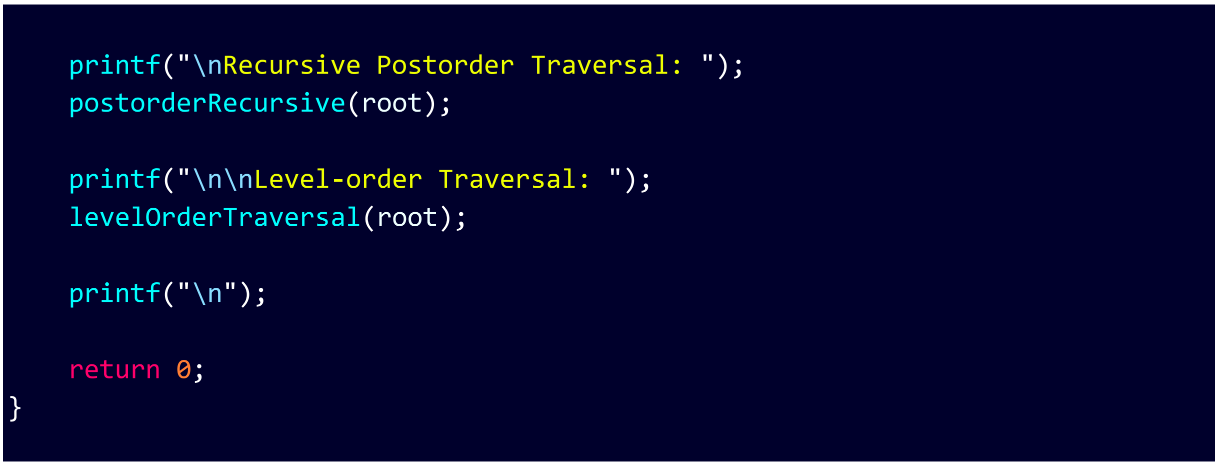
Q11) Write a program in C to implement binary trees operations and traversals .

Code

```
#include <stdio.h>
#include <stdlib.h>

// Define the structure for tree node
typedef struct Node {
    int data;
    struct Node* left;
    struct Node* right;
} Node;

// Define queue structure for level order operations
typedef struct QueueNode {
    Node* treeNode;
    struct QueueNode* next;
} QueueNode;

typedef struct Queue {
    QueueNode *front, *rear;
} Queue;

// Function to create a new tree node
Node* createNode(int data) {
    Node* newNode = (Node*)malloc(sizeof(Node));
    newNode->data = data;
    newNode->left = newNode->right = NULL;
    return newNode;
}

// ----------------- Queue Functions -----------------
Queue* createQueue() {
    Queue* q = (Queue*)malloc(sizeof(Queue));
    q->front = q->rear = NULL;
    return q;
}

void enqueue(Queue* q, Node* node) {
    QueueNode* temp = (QueueNode*)malloc(sizeof(QueueNode));
    temp->treeNode = node;
    temp->next = NULL;
    if (q->rear == NULL) {
        q->front = q->rear = temp;
        return;
    }
    q->rear->next = temp;
    q->rear = temp;
```

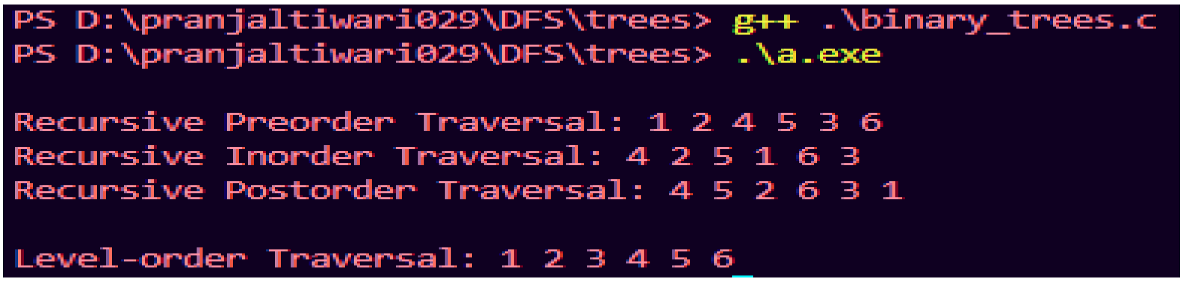


```c
}

Node* dequeue(Queue* q) {
    if (q->front == NULL)
        return NULL;
    QueueNode* temp = q->front;
    Node* node = temp->treeNode;
    q->front = q->front->next;
    if (q->front == NULL)
        q->rear = NULL;
    free(temp);
    return node;
}

int isQueueEmpty(Queue* q) {
    return q->front == NULL;
}

// ----------------- Build Tree using Level Order -----------------
Node* buildTree(int arr[], int n) {
    if (n == 0)
        return NULL;

    Node* root = createNode(arr[0]);
    Queue* q = createQueue();
    enqueue(q, root);

    int i = 1;
    while (i < n) {
        Node* temp = dequeue(q);

        if (i < n) {
            temp->left = createNode(arr[i++]);
            enqueue(q, temp->left);
        }
        if (i < n) {
            temp->right = createNode(arr[i++]);
            enqueue(q, temp->right);
        }
    }
    return root;
}

// ----------------- Recursive Traversals -----------------
void preorderRecursive(Node* root) {
    if (root == NULL)
        return;
    printf("%d ", root->data);
    preorderRecursive(root->left);
    preorderRecursive(root->right);
}

void inorderRecursive(Node* root) {
    if (root == NULL)
        return;
    inorderRecursive(root->left);
    printf("%d ", root->data);
    inorderRecursive(root->right);
}

void postorderRecursive(Node* root) {
    if (root == NULL)
        return;
    postorderRecursive(root->left);
    postorderRecursive(root->right);
    printf("%d ", root->data);
}

// ----------------- Level-order Traversal -----------------
void levelOrderTraversal(Node* root) {
    if (root == NULL)
        return;
    Queue* q = createQueue();
    enqueue(q, root);
    while (!isQueueEmpty(q)) {
        Node* temp = dequeue(q);
        printf("%d ", temp->data);
        if (temp->left)
            enqueue(q, temp->left);
        if (temp->right)
            enqueue(q, temp->right);
    }
}

// ----------------- Main Function -----------------
int main() {
    int arr[] = {1, 2, 3, 4, 5, 6}; // Sample input
    int n = sizeof(arr) / sizeof(arr[0]);

    Node* root = buildTree(arr, n);

    printf("\nRecursive Preorder Traversal: ");
    preorderRecursive(root);

    printf("\nRecursive Inorder Traversal: ");
    inorderRecursive(root);
```



```
    printf("\nRecursive Postorder Traversal: ");
    postorderRecursive(root);

    printf("\n\nLevel-order Traversal: ");
    levelOrderTraversal(root);

    printf("\n");

    return 0;
}
```

OUTPUT

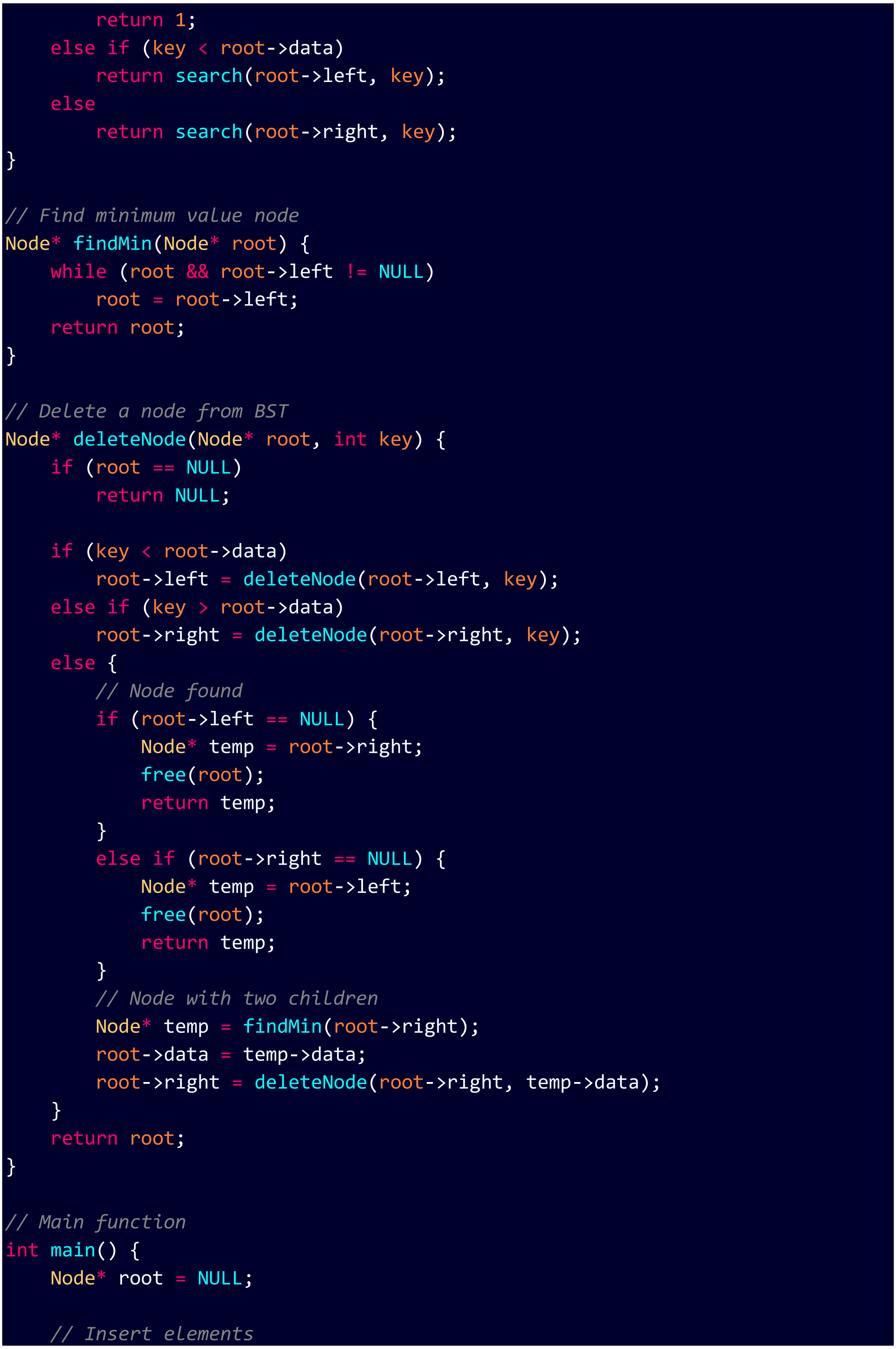


```
PS D:\pranjaltiwari029\DFS\trees> g++ .\binary_trees.c
PS D:\pranjaltiwari029\DFS\trees> .\a.exe

Recursive Preorder Traversal: 1 2 4 5 3 6
Recursive Inorder Traversal: 4 2 5 1 6 3
Recursive Postorder Traversal: 4 5 2 6 3 1

Level-order Traversal: 1 2 3 4 5 6
```

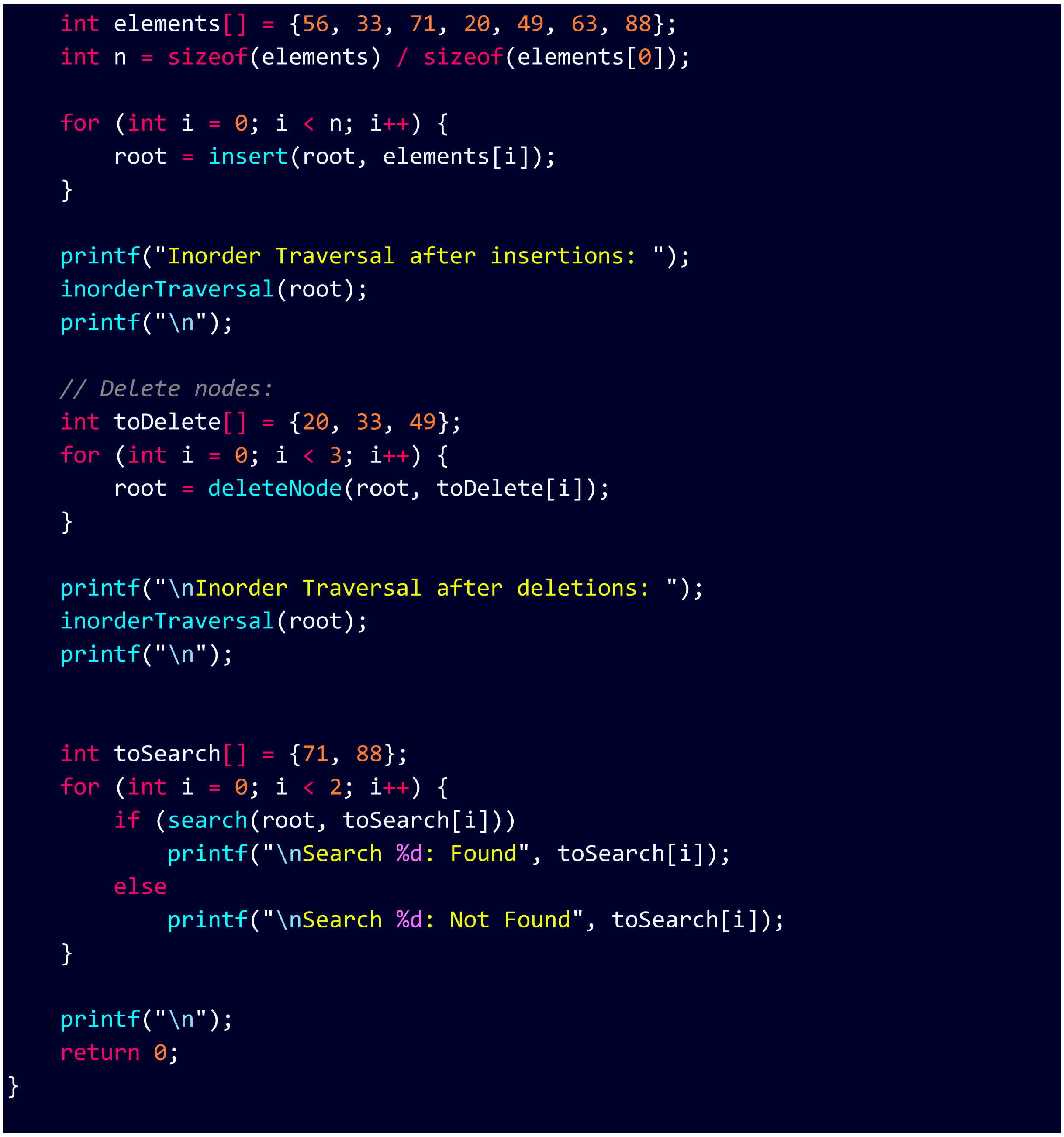
Q12) Write a program in C to implement binary search trees

Code

```c
#include <stdio.h>
#include <stdlib.h>

// Node structure
typedef struct Node {
    int data;
    struct Node* left;
    struct Node* right;
} Node;

// Function to create a new node
Node* createNode(int data) {
    Node* newNode = (Node*)malloc(sizeof(Node));
    newNode->data = data;
    newNode->left = newNode->right = NULL;
    return newNode;
}

// Insert into BST
Node* insert(Node* root, int data) {
    if (root == NULL)
        return createNode(data);

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

    return root;
}

// Inorder Traversal
void inorderTraversal(Node* root) {
    if (root == NULL)
        return;
    inorderTraversal(root->left);
    printf("%d ", root->data);
    inorderTraversal(root->right);
}

// Search in BST
int search(Node* root, int key) {
    if (root == NULL)
        return 0;
    if (root->data == key)
```

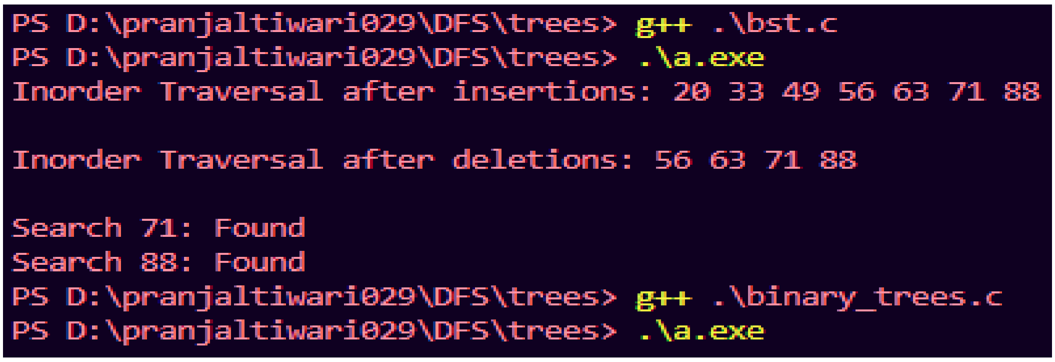


```
        return 1;
    else if (key < root->data)
        return search(root->left, key);
    else
        return search(root->right, key);
}

// Find minimum value node
Node* findMin(Node* root) {
    while (root && root->left != NULL)
        root = root->left;
    return root;
}

// Delete a node from BST
Node* deleteNode(Node* root, int key) {
    if (root == NULL)
        return NULL;

    if (key < root->data)
        root->left = deleteNode(root->left, key);
    else if (key > root->data)
        root->right = deleteNode(root->right, key);
    else {
        // Node found
        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
        Node* temp = findMin(root->right);
        root->data = temp->data;
        root->right = deleteNode(root->right, temp->data);
    }
    return root;
}

// Main function
int main() {
    Node* root = NULL;

    // Insert elements
```



```c
    int elements[] = {56, 33, 71, 20, 49, 63, 88};
    int n = sizeof(elements) / sizeof(elements[0]);

    for (int i = 0; i < n; i++) {
        root = insert(root, elements[i]);
    }

    printf("Inorder Traversal after insertions: ");
    inorderTraversal(root);
    printf("\n");

    // Delete nodes:
    int toDelete[] = {20, 33, 49};
    for (int i = 0; i < 3; i++) {
        root = deleteNode(root, toDelete[i]);
    }

    printf("\nInorder Traversal after deletions: ");
    inorderTraversal(root);
    printf("\n");


    int toSearch[] = {71, 88};
    for (int i = 0; i < 2; i++) {
        if (search(root, toSearch[i]))
            printf("\nSearch %d: Found", toSearch[i]);
        else
            printf("\nSearch %d: Not Found", toSearch[i]);
    }

    printf("\n");
    return 0;
}
```

Output

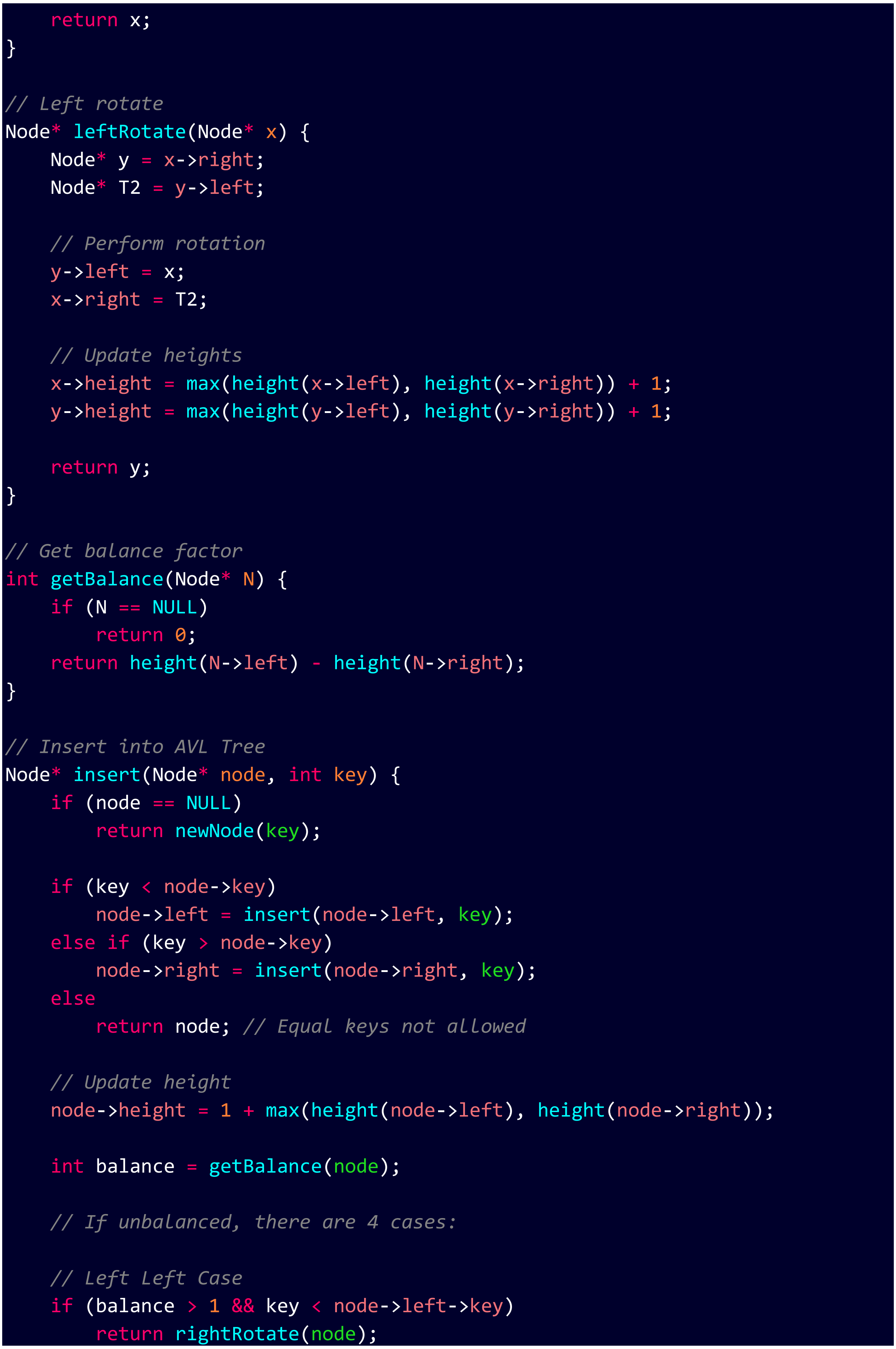


```
PS D:\pranjaltiwari029\DFS\trees> g++ .\bst.c
PS D:\pranjaltiwari029\DFS\trees> .\a.exe
Inorder Traversal after insertions: 20 33 49 56 63 71 88

Inorder Traversal after deletions: 56 63 71 88

Search 71: Found
Search 88: Found
PS D:\pranjaltiwari029\DFS\trees> g++ .\binary_trees.c
PS D:\pranjaltiwari029\DFS\trees> .\a.exe
```

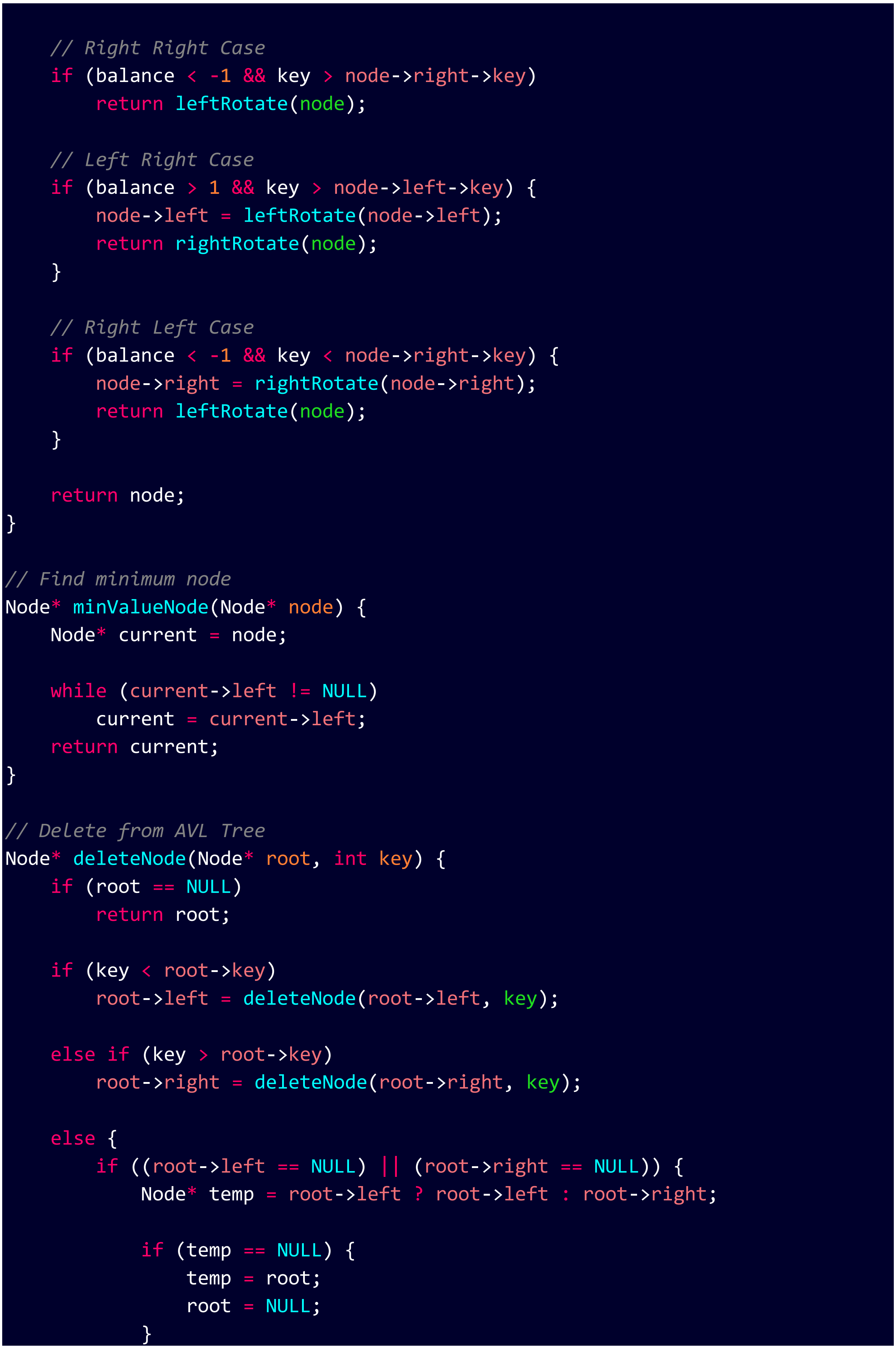
Q13) Write a program in C to implement avl trees

Code

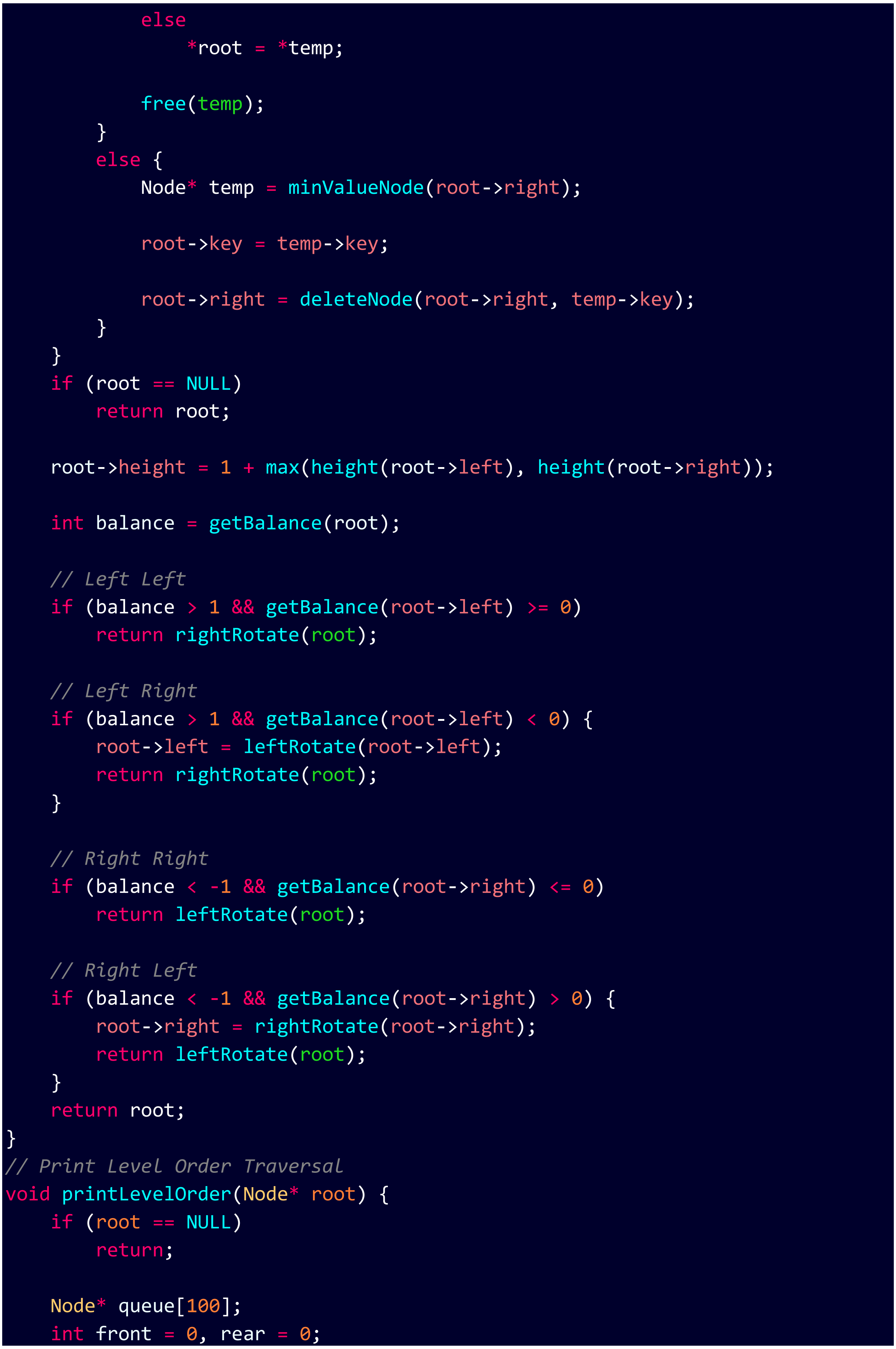
```
#include <stdio.h>
#include <stdlib.h>

// AVL Tree Node
typedef struct Node {
    int key;
    struct Node* left;
    struct Node* right;
    int height;
} Node;

// Utility to get max
int max(int a, int b) {
    return (a > b) ? a : b;
}

// Get height of node
int height(Node* N) {
    if (N == NULL)
        return 0;
    return N->height;
}

// Create a new node
Node* newNode(int key) {
    Node* node = (Node*)malloc(sizeof(Node));
    node->key = key;
    node->left = node->right = NULL;
    node->height = 1; // New node is initially at height 1
    return node;
}

// Right rotate
Node* rightRotate(Node* y) {
    Node* x = y->left;
    Node* T2 = x->right;

    // Perform rotation
    x->right = y;
    y->left = T2;

    // Update heights
    y->height = max(height(y->left), height(y->right)) + 1;
    x->height = max(height(x->left), height(x->right)) + 1;
```



```c
    return x;
}

// Left rotate
Node* leftRotate(Node* x) {
    Node* y = x->right;
    Node* T2 = y->left;

    // Perform rotation
    y->left = x;
    x->right = T2;

    // Update heights
    x->height = max(height(x->left), height(x->right)) + 1;
    y->height = max(height(y->left), height(y->right)) + 1;

    return y;
}

// Get balance factor
int getBalance(Node* N) {
    if (N == NULL)
        return 0;
    return height(N->left) - height(N->right);
}

// Insert into AVL Tree
Node* insert(Node* node, int key) {
    if (node == NULL)
        return newNode(key);

    if (key < node->key)
        node->left = insert(node->left, key);
    else if (key > node->key)
        node->right = insert(node->right, key);
    else
        return node; // Equal keys not allowed

    // Update height
    node->height = 1 + max(height(node->left), height(node->right));

    int balance = getBalance(node);

    // If unbalanced, there are 4 cases:

    // Left Left Case
    if (balance > 1 && key < node->left->key)
        return rightRotate(node);
```

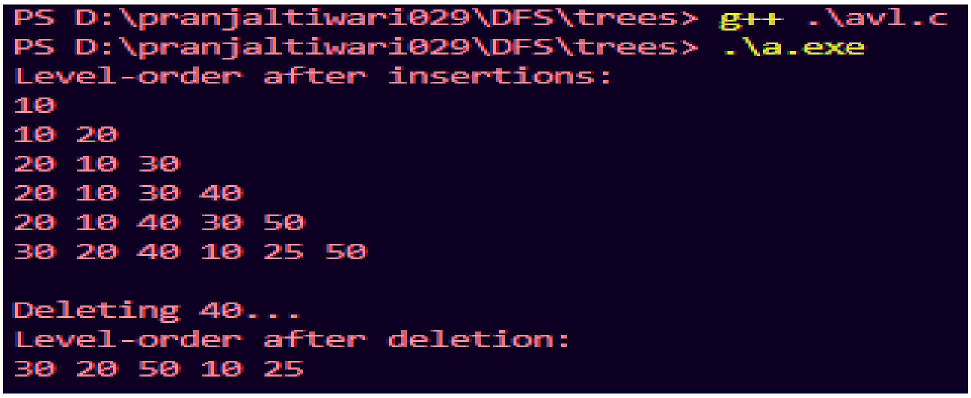


```
    // Right Right Case
    if (balance < -1 && key > node->right->key)
        return leftRotate(node);

    // Left Right Case
    if (balance > 1 && key > node->left->key) {
        node->left = leftRotate(node->left);
        return rightRotate(node);
    }

    // Right Left Case
    if (balance < -1 && key < node->right->key) {
        node->right = rightRotate(node->right);
        return leftRotate(node);
    }

    return node;
}

// Find minimum node
Node* minValueNode(Node* node) {
    Node* current = node;

    while (current->left != NULL)
        current = current->left;
    return current;
}

// Delete from AVL Tree
Node* deleteNode(Node* root, int key) {
    if (root == NULL)
        return root;

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

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

    else {
        if ((root->left == NULL) || (root->right == NULL)) {
            Node* temp = root->left ? root->left : root->right;

            if (temp == NULL) {
                temp = root;
                root = NULL;
            }
```



```
            else
                *root = *temp;

            free(temp);
        }
        else {
            Node* temp = minValueNode(root->right);

            root->key = temp->key;

            root->right = deleteNode(root->right, temp->key);
        }
    }
    if (root == NULL)
        return root;

    root->height = 1 + max(height(root->left), height(root->right));

    int balance = getBalance(root);

    // Left Left
    if (balance > 1 && getBalance(root->left) >= 0)
        return rightRotate(root);

    // Left Right
    if (balance > 1 && getBalance(root->left) < 0) {
        root->left = leftRotate(root->left);
        return rightRotate(root);
    }

    // Right Right
    if (balance < -1 && getBalance(root->right) <= 0)
        return leftRotate(root);

    // Right Left
    if (balance < -1 && getBalance(root->right) > 0) {
        root->right = rightRotate(root->right);
        return leftRotate(root);
    }
    return root;
}
// Print Level Order Traversal
void printLevelOrder(Node* root) {
    if (root == NULL)
        return;

    Node* queue[100];
    int front = 0, rear = 0;
    queue[rear++] = root;

    while (front < rear) {
        Node* current = queue[front++];
        printf("%d ", current->key);

        if (current->left != NULL)
            queue[rear++] = current->left;
        if (current->right != NULL)
            queue[rear++] = current->right;
    }
}
int main() {
    Node* root = NULL;

    int insert_elements[] = {10, 20, 30, 40, 50, 25};
    int n = sizeof(insert_elements) / sizeof(insert_elements[0]);

    printf("Level-order after insertions:\n");
    for (int i = 0; i < n; i++) {
        root = insert(root, insert_elements[i]);
        printLevelOrder(root);
        printf("\n");
    }

    printf("\nDeleting 40...\n");
    root = deleteNode(root, 40);

    printf("Level-order after deletion:\n");
    printLevelOrder(root);
    printf("\n");

    return 0;
}
```

Output

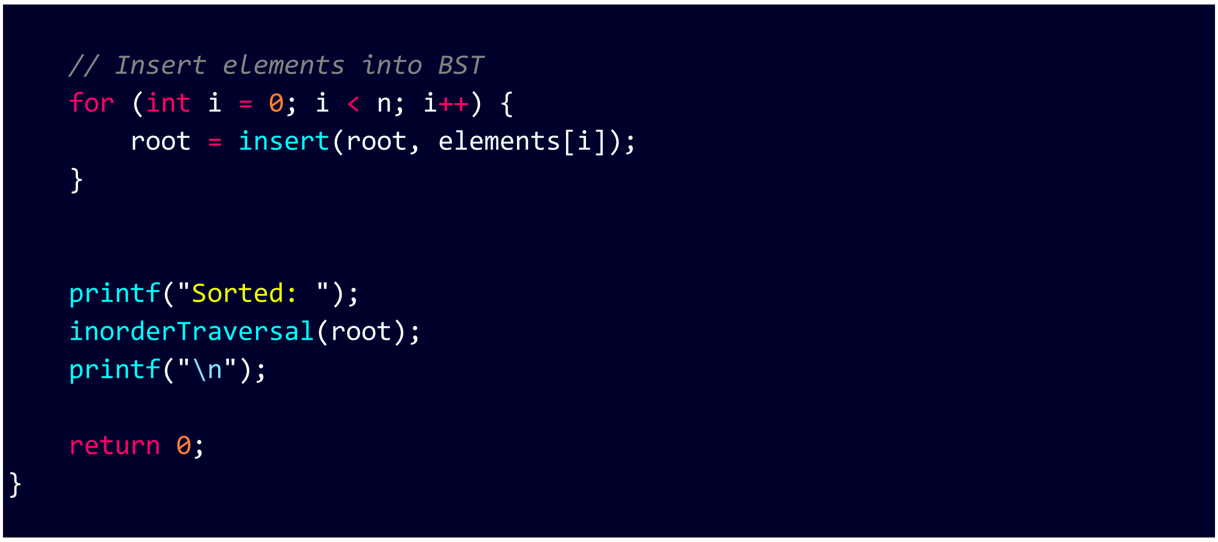


```
PS D:\pranjaltiwari029\DFS\trees> g++ .\avl.c
PS D:\pranjaltiwari029\DFS\trees> .\a.exe
Level-order after insertions:
10
10 20
20 10 30
20 10 30 40
20 10 40 30 50
30 20 40 10 25 50

Deleting 40...
Level-order after deletion:
30 20 50 10 25
```

Q14) Write a program in C to implement Tree Sort using BST.

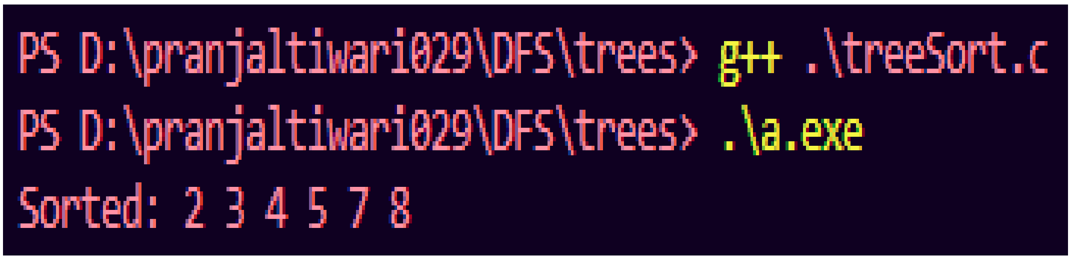
Code

```c
#include <stdio.h>
#include <stdlib.h>

// Define a BST node
typedef struct Node {
    int key;
    struct Node* left;
    struct Node* right;
} Node;

// Create a new node
Node* newNode(int key) {
    Node* node = (Node*)malloc(sizeof(Node));
    node->key = key;
    node->left = node->right = NULL;
    return node;
}

// Insert into BST
Node* insert(Node* root, int key) {
    if (root == NULL)
        return newNode(key);

    if (key < root->key)
        root->left = insert(root->left, key);
    else
        root->right = insert(root->right, key);

    return root;
}

// Inorder Traversal (prints sorted elements)
void inorderTraversal(Node* root) {
    if (root != NULL) {
        inorderTraversal(root->left);
        printf("%d ", root->key);
        inorderTraversal(root->right);
    }
}

int main() {
    int elements[] = {5, 3, 7, 2, 8, 4};
    int n = sizeof(elements) / sizeof(elements[0]);

    Node* root = NULL;
```



```c
    // Insert elements into BST
    for (int i = 0; i < n; i++) {
        root = insert(root, elements[i]);
    }


    printf("Sorted: ");
    inorderTraversal(root);
    printf("\n");

    return 0;
}
```

Output



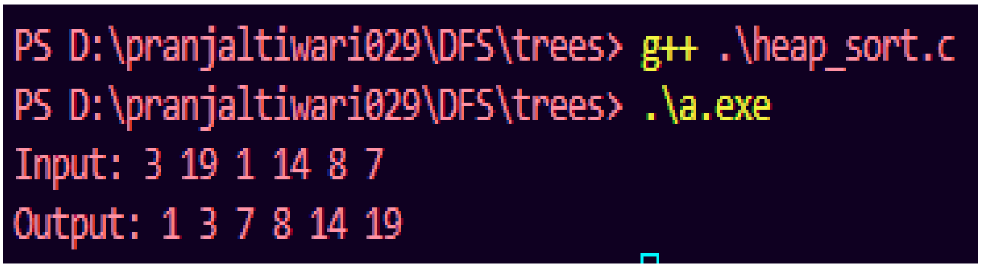
```
PS D:\pranjaltiwari029\DFS\trees> g++ .\treeSort.c
PS D:\pranjaltiwari029\DFS\trees> .\a.exe
Sorted: 2 3 4 5 7 8
```

Q16) Write a program in C to implement heap sort.

Code

```c
#include <stdio.h>


// Function to heapify a subtree rooted at index i in a max heap
void heapify(int arr[], int n, int i) {
    int largest = i;        // Initialize largest as root
    int left = 2 * i + 1;   // Left child index
    int right = 2 * i + 2;  // Right child index

    // If left child is larger than root
    if (left < n && arr[left] > arr[largest]) {
        largest = left;
    }

    // If right child is larger than the largest so far
    if (right < n && arr[right] > arr[largest]) {
        largest = right;
    }

    // If largest is not root
    if (largest != i) {
        // Swap root and largest
        int temp = arr[i];
        arr[i] = arr[largest];
        arr[largest] = temp;

        // Recursively heapify the affected subtree
        heapify(arr, n, largest);
    }
}

// Function to perform heap sort
void heapSort(int arr[], int n) {
    // Build a max heap (rearrange array)
    for (int i = n / 2 - 1; i >= 0; i--) {
        heapify(arr, n, i);
    }

    // One by one extract elements from the heap
    for (int i = n - 1; i > 0; i--) {
        // Swap current root with the end element
        int temp = arr[0];
        arr[0] = arr[i];
        arr[i] = temp;

        // Call heapify on the reduced heap
        heapify(arr, i, 0);
    }
}

// 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[] = {3, 19, 1, 14, 8, 7};
    int n = sizeof(arr) / sizeof(arr[0]);

    printf("Input: ");
    printArray(arr, n);

    heapSort(arr, n);

    printf("Output: ");
    printArray(arr, n);

    return 0;
}
```

Output

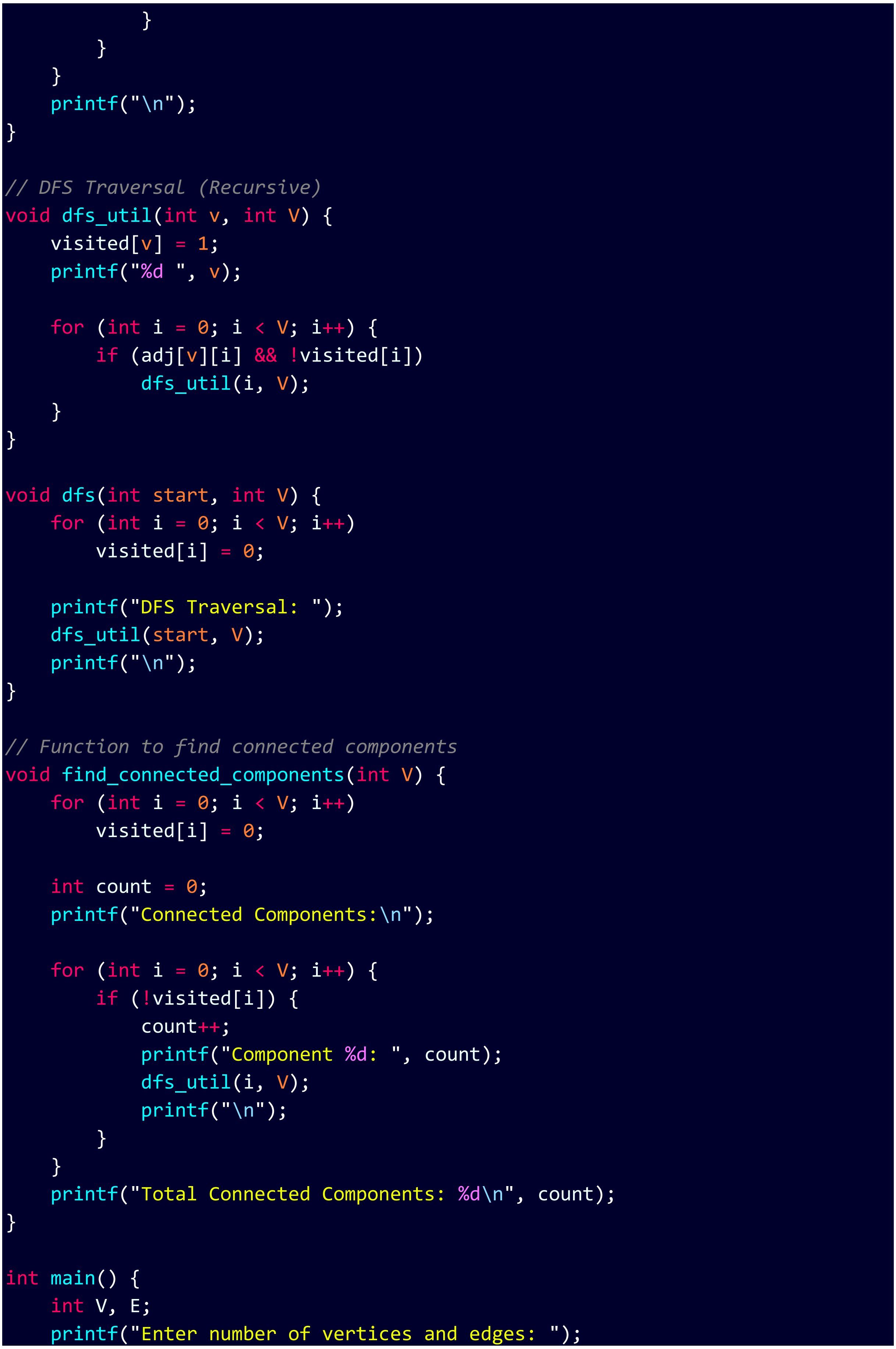


```
PS D:\pranjaltiwari029\DFS\trees> g++ .\heap_sort.c
PS D:\pranjaltiwari029\DFS\trees> .\a.exe
Input: 3 19 1 14 8 7
Output: 1 3 7 8 14 19
```

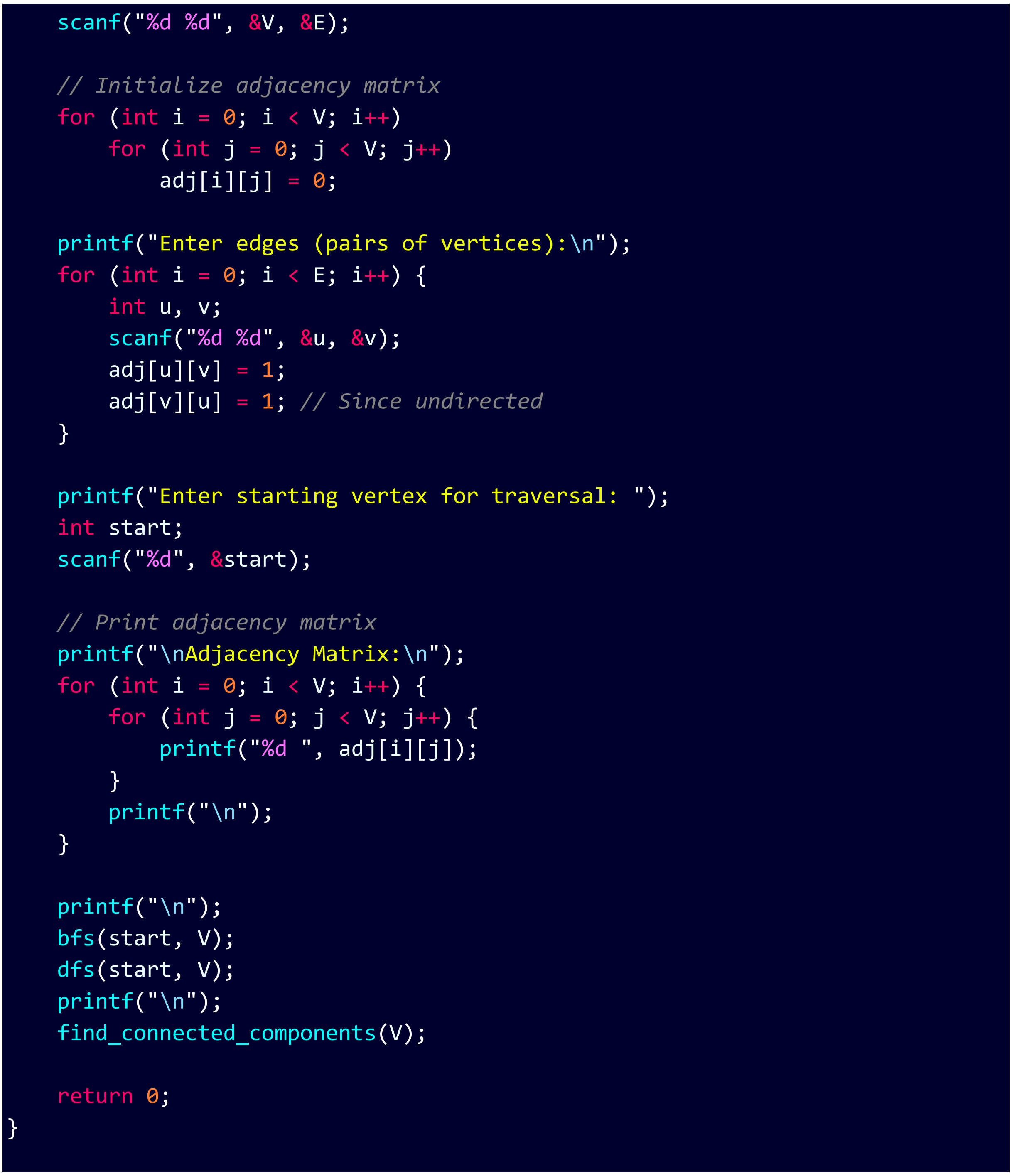
Q18) Write a program in C to implement Graph Traversals & Connected Components using Adjacency Matrix

Code

```
#include <stdio.h>
#include <stdlib.h>

#define MAX 100

int adj[MAX][MAX];     // Adjacency matrix
int visited[MAX];      // Visited array
int queue[MAX];        // Queue for BFS
int front = -1, rear = -1;

// Function to insert into queue
void enqueue(int v) {
    if (rear == MAX - 1)
        return;
    if (front == -1)
        front = 0;
    queue[++rear] = v;
}

// Function to delete from queue
int dequeue() {
    if (front == -1 || front > rear)
        return -1;
    return queue[front++];
}

// BFS Traversal
void bfs(int start, int V) {
    for (int i = 0; i < V; i++)
        visited[i] = 0;

    enqueue(start);
    visited[start] = 1;

    printf("BFS Traversal: ");

    while (front <= rear) {
        int current = dequeue();
        printf("%d ", current);

        for (int i = 0; i < V; i++) {
            if (adj[current][i] && !visited[i]) {
                enqueue(i);
                visited[i] = 1;
```

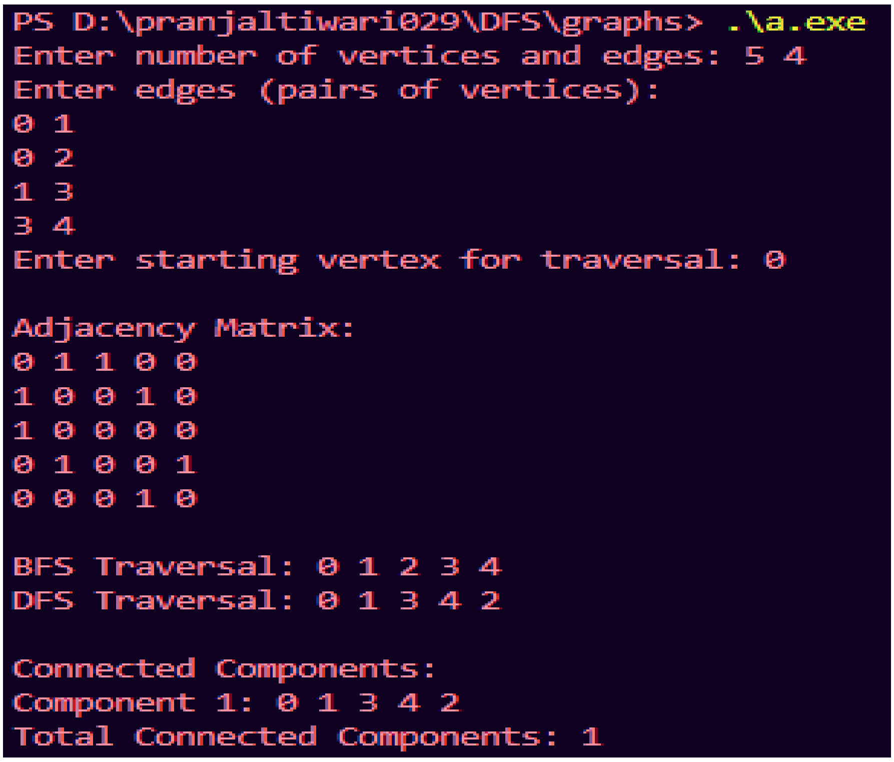


```c
            }
        }
    }
    printf("\n");
}

// DFS Traversal (Recursive)
void dfs_util(int v, int V) {
    visited[v] = 1;
    printf("%d ", v);

    for (int i = 0; i < V; i++) {
        if (adj[v][i] && !visited[i])
            dfs_util(i, V);
    }
}

void dfs(int start, int V) {
    for (int i = 0; i < V; i++)
        visited[i] = 0;

    printf("DFS Traversal: ");
    dfs_util(start, V);
    printf("\n");
}

// Function to find connected components
void find_connected_components(int V) {
    for (int i = 0; i < V; i++)
        visited[i] = 0;

    int count = 0;
    printf("Connected Components:\n");

    for (int i = 0; i < V; i++) {
        if (!visited[i]) {
            count++;
            printf("Component %d: ", count);
            dfs_util(i, V);
            printf("\n");
        }
    }
    printf("Total Connected Components: %d\n", count);
}

int main() {
    int V, E;
    printf("Enter number of vertices and edges: ");
```



```
    scanf("%d %d", &V, &E);

    // Initialize adjacency matrix
    for (int i = 0; i < V; i++)
        for (int j = 0; j < V; j++)
            adj[i][j] = 0;

    printf("Enter edges (pairs of vertices):\n");
    for (int i = 0; i < E; i++) {
        int u, v;
        scanf("%d %d", &u, &v);
        adj[u][v] = 1;
        adj[v][u] = 1; // Since undirected
    }

    printf("Enter starting vertex for traversal: ");
    int start;
    scanf("%d", &start);

    // Print adjacency matrix
    printf("\nAdjacency Matrix:\n");
    for (int i = 0; i < V; i++) {
        for (int j = 0; j < V; j++) {
            printf("%d ", adj[i][j]);
        }
        printf("\n");
    }

    printf("\n");
    bfs(start, V);
    dfs(start, V);
    printf("\n");
    find_connected_components(V);

    return 0;
}
```

Output

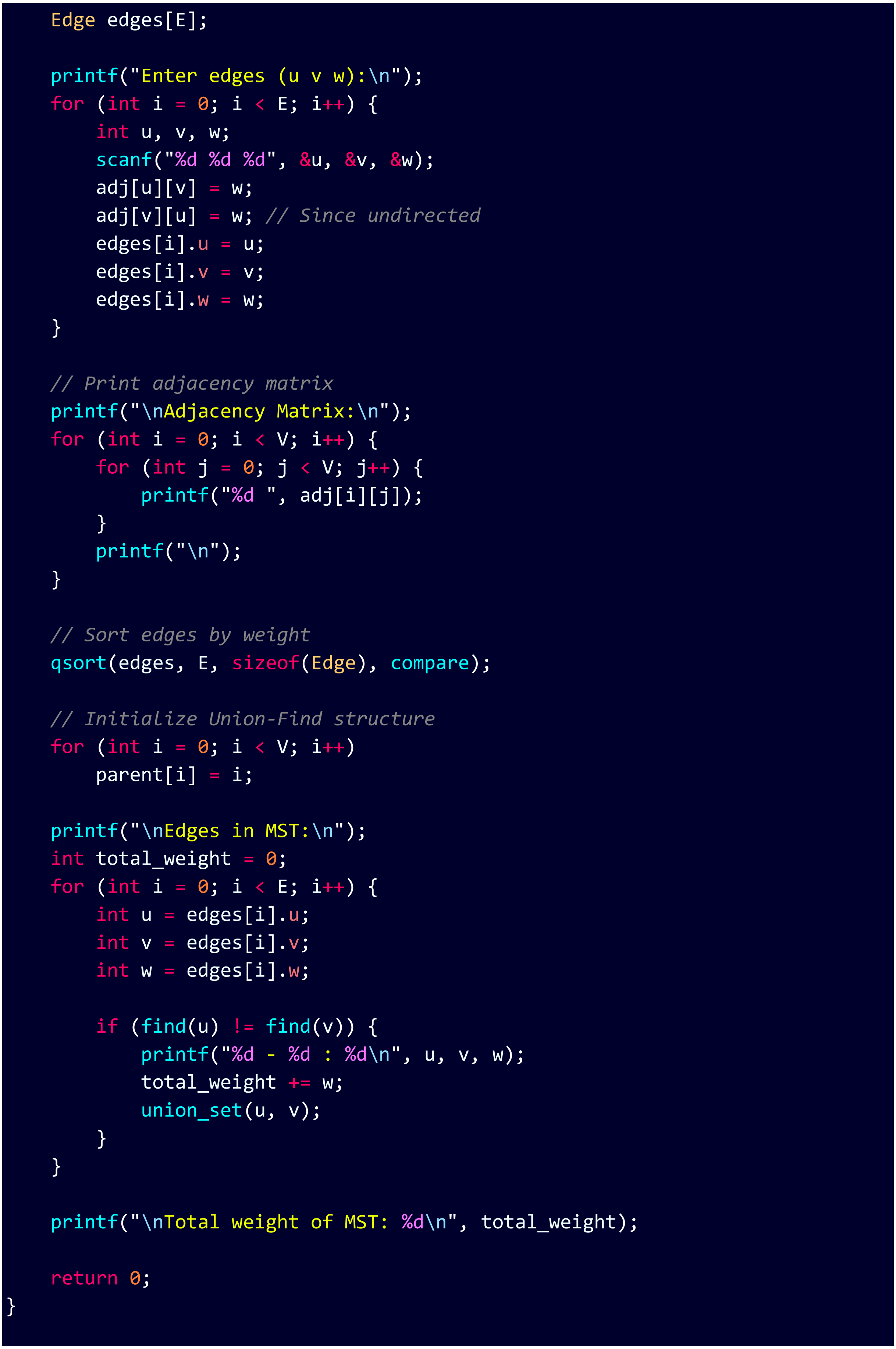


```
PS D:\pranjaltiwari029\DFS\graphs> .\a.exe
Enter number of vertices and edges: 5 4
Enter edges (pairs of vertices):
0 1
0 2
1 3
3 4
Enter starting vertex for traversal: 0

Adjacency Matrix:
0 1 1 0 0
1 0 0 1 0
1 0 0 0 0
0 1 0 0 1
0 0 0 1 0

BFS Traversal: 0 1 2 3 4
DFS Traversal: 0 1 3 4 2

Connected Components:
Component 1: 0 1 3 4 2
Total Connected Components: 1
```

Q19) Write a program in C to implement Krushkal’s Algorithm

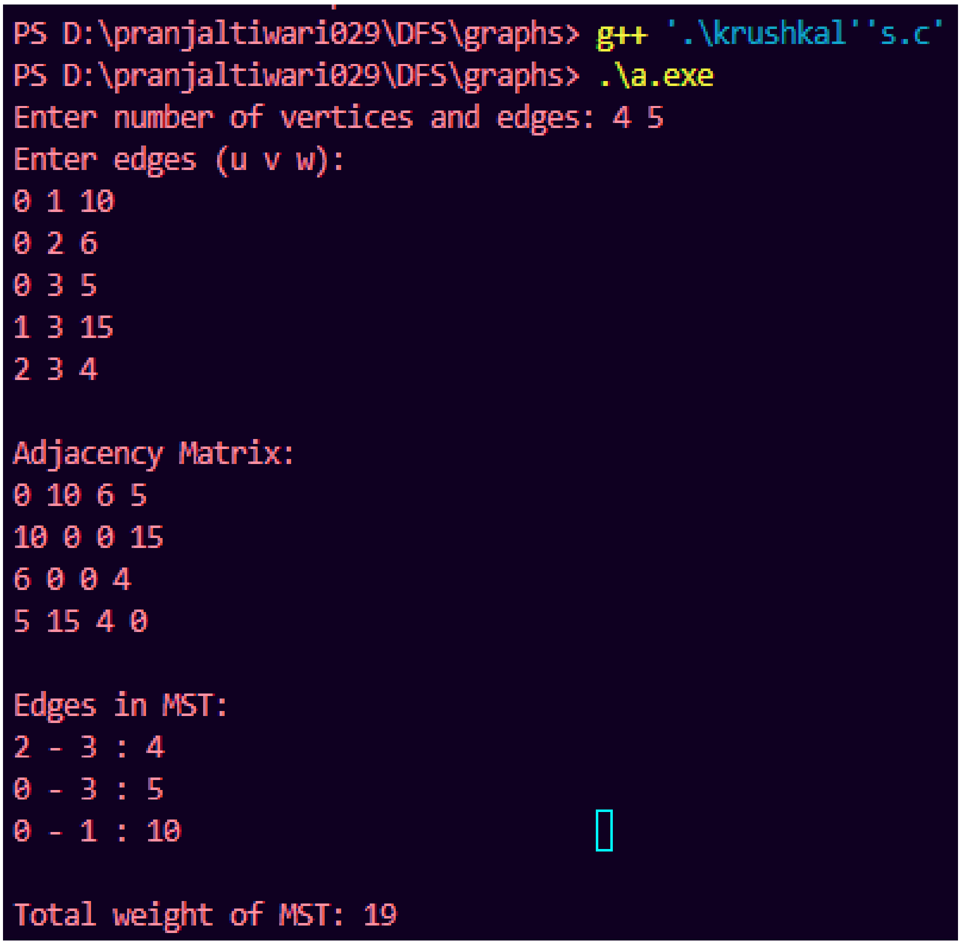
Code

```
#include <stdio.h>
#include <stdlib.h>

#define MAX 100

// Structure to represent an edge
typedef struct {
    int u, v, w;
} Edge;

int adj[MAX][MAX];
int parent[MAX];

// Find function for Union-Find
int find(int i) {
    if (parent[i] == i)
        return i;
    return parent[i] = find(parent[i]); // Path compression
}

// Union function for Union-Find
void union_set(int u, int v) {
    int pu = find(u);
    int pv = find(v);
    if (pu != pv)
        parent[pu] = pv;
}

// Compare function for qsort
int compare(const void *a, const void *b) {
    Edge *e1 = (Edge *)a;
    Edge *e2 = (Edge *)b;
    return e1->w - e2->w;
}

int main() {
    int V, E;
    printf("Enter number of vertices and edges: ");
    scanf("%d %d", &V, &E);

    // Initialize adjacency matrix
    for (int i = 0; i < V; i++)
        for (int j = 0; j < V; j++)
            adj[i][j] = 0;
```



```
    Edge edges[E];

    printf("Enter edges (u v w):\n");
    for (int i = 0; i < E; i++) {
        int u, v, w;
        scanf("%d %d %d", &u, &v, &w);
        adj[u][v] = w;
        adj[v][u] = w; // Since undirected
        edges[i].u = u;
        edges[i].v = v;
        edges[i].w = w;
    }

    // Print adjacency matrix
    printf("\nAdjacency Matrix:\n");
    for (int i = 0; i < V; i++) {
        for (int j = 0; j < V; j++) {
            printf("%d ", adj[i][j]);
        }
        printf("\n");
    }

    // Sort edges by weight
    qsort(edges, E, sizeof(Edge), compare);

    // Initialize Union-Find structure
    for (int i = 0; i < V; i++)
        parent[i] = i;

    printf("\nEdges in MST:\n");
    int total_weight = 0;
    for (int i = 0; i < E; i++) {
        int u = edges[i].u;
        int v = edges[i].v;
        int w = edges[i].w;

        if (find(u) != find(v)) {
            printf("%d - %d : %d\n", u, v, w);
            total_weight += w;
            union_set(u, v);
        }
    }

    printf("\nTotal weight of MST: %d\n", total_weight);

    return 0;
}
```

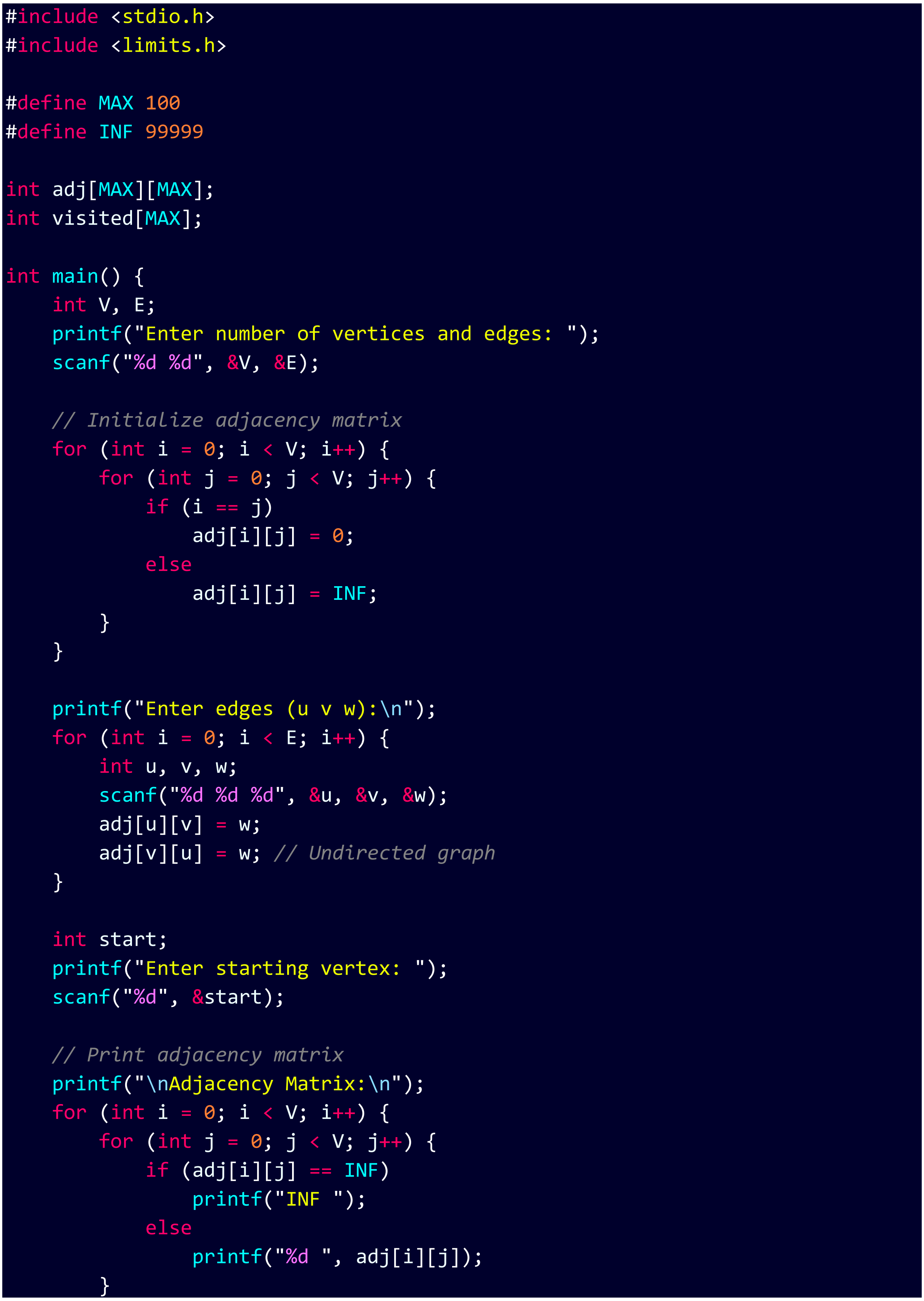
Output



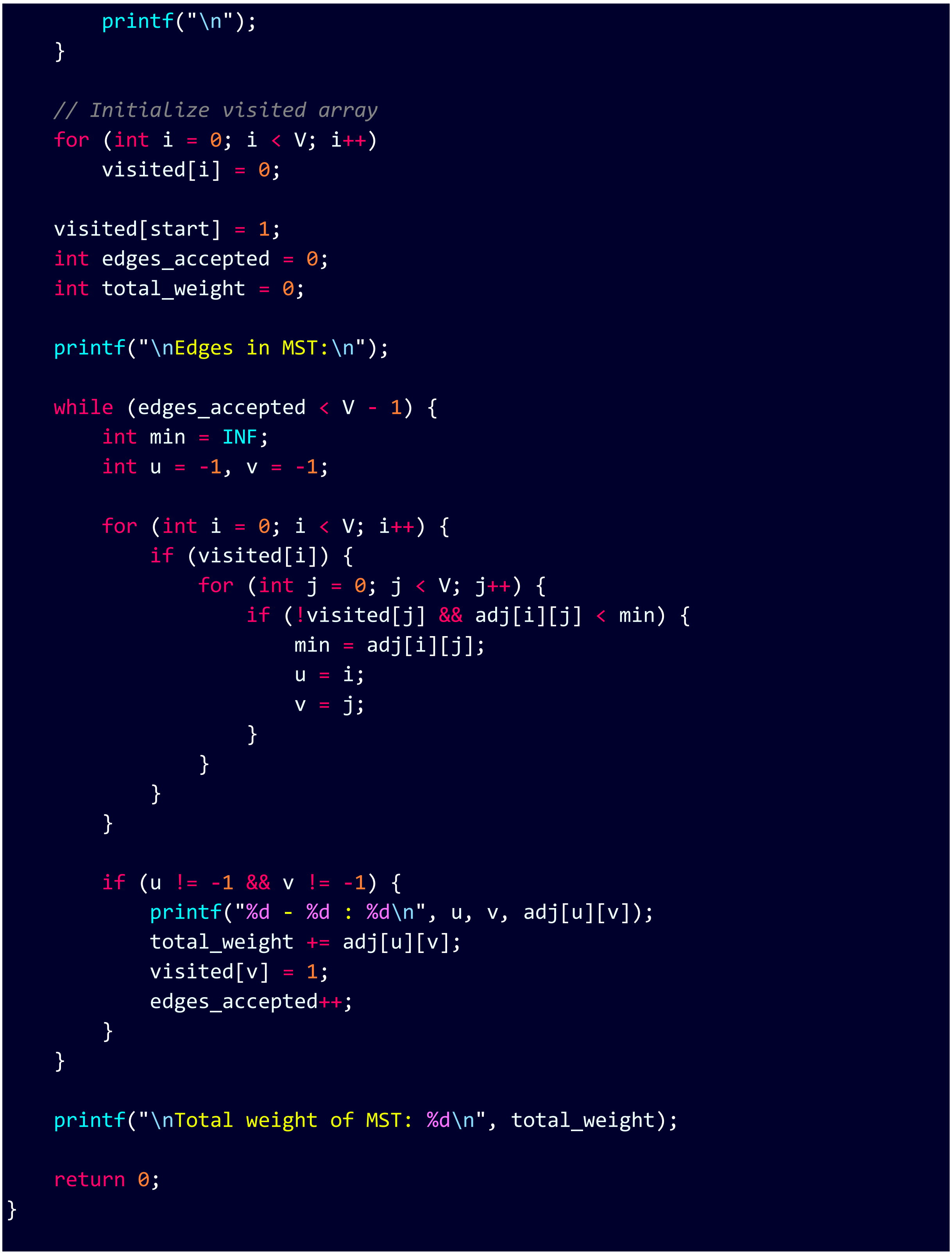
```
PS D:\pranjaltiwari029\DFS\graphs> g++ '.\krushkal''s.c'
PS D:\pranjaltiwari029\DFS\graphs> .\a.exe
Enter number of vertices and edges: 4 5
Enter edges (u v w):
0 1 10
0 2 6
0 3 5
1 3 15
2 3 4

Adjacency Matrix:
0 10 6 5
10 0 0 15
6 0 0 4
5 15 4 0

Edges in MST:
2 - 3 : 4
0 - 3 : 5
0 - 1 : 10

Total weight of MST: 19
```

Q20) Write a program in C to implement Prim's Algorithm for MST

Code

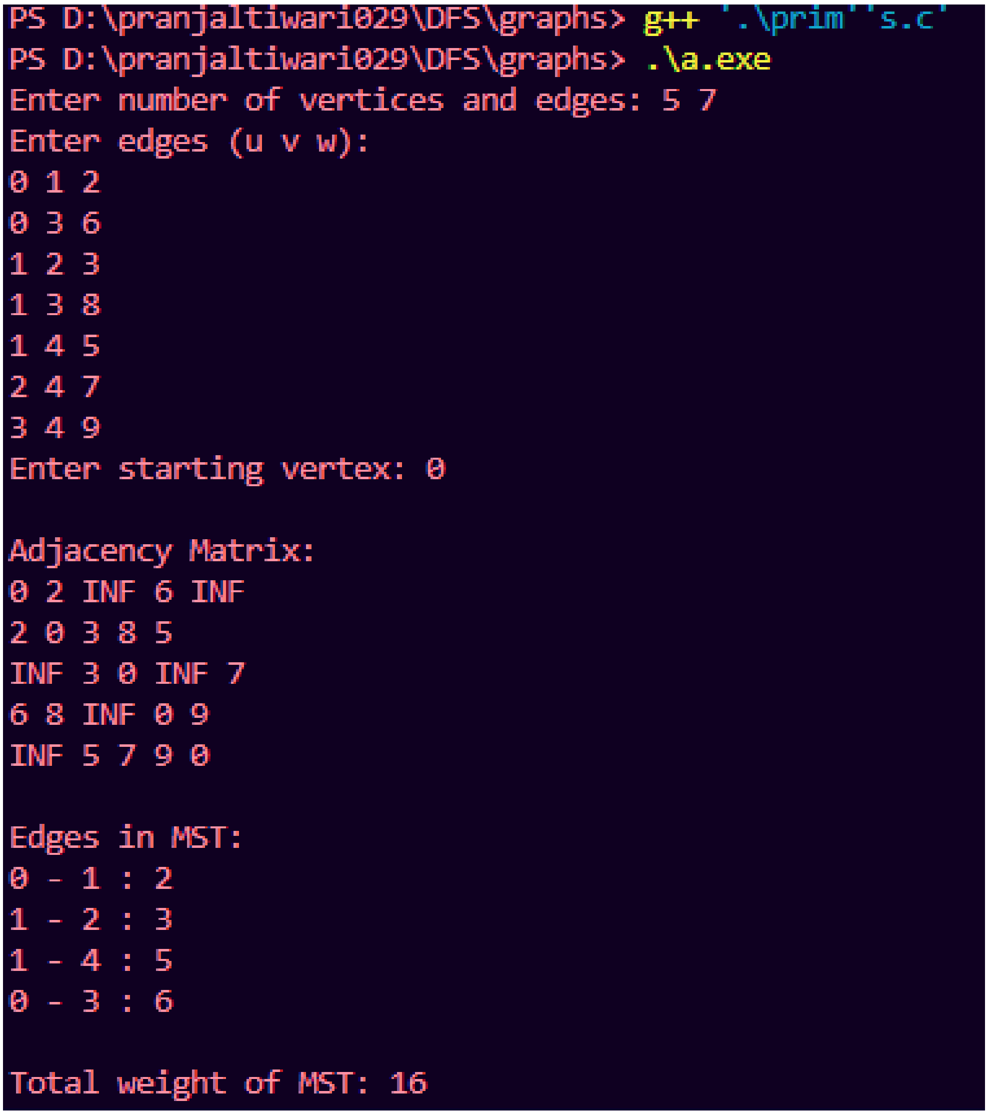


```c
#include <stdio.h>
#include <limits.h>

#define MAX 100
#define INF 99999

int adj[MAX][MAX];
int visited[MAX];

int main() {
    int V, E;
    printf("Enter number of vertices and edges: ");
    scanf("%d %d", &V, &E);

    // Initialize adjacency matrix
    for (int i = 0; i < V; i++) {
        for (int j = 0; j < V; j++) {
            if (i == j)
                adj[i][j] = 0;
            else
                adj[i][j] = INF;
        }
    }

    printf("Enter edges (u v w):\n");
    for (int i = 0; i < E; i++) {
        int u, v, w;
        scanf("%d %d %d", &u, &v, &w);
        adj[u][v] = w;
        adj[v][u] = w; // Undirected graph
    }

    int start;
    printf("Enter starting vertex: ");
    scanf("%d", &start);

    // Print adjacency matrix
    printf("\nAdjacency Matrix:\n");
    for (int i = 0; i < V; i++) {
        for (int j = 0; j < V; j++) {
            if (adj[i][j] == INF)
                printf("INF ");
            else
                printf("%d ", adj[i][j]);
        }
```



```
        printf("\n");
    }

    // Initialize visited array
    for (int i = 0; i < V; i++)
        visited[i] = 0;

    visited[start] = 1;
    int edges_accepted = 0;
    int total_weight = 0;

    printf("\nEdges in MST:\n");

    while (edges_accepted < V - 1) {
        int min = INF;
        int u = -1, v = -1;

        for (int i = 0; i < V; i++) {
            if (visited[i]) {
                for (int j = 0; j < V; j++) {
                    if (!visited[j] && adj[i][j] < min) {
                        min = adj[i][j];
                        u = i;
                        v = j;
                    }
                }
            }
        }

        if (u != -1 && v != -1) {
            printf("%d - %d : %d\n", u, v, adj[u][v]);
            total_weight += adj[u][v];
            visited[v] = 1;
            edges_accepted++;
        }
    }

    printf("\nTotal weight of MST: %d\n", total_weight);

    return 0;
}
```

Output

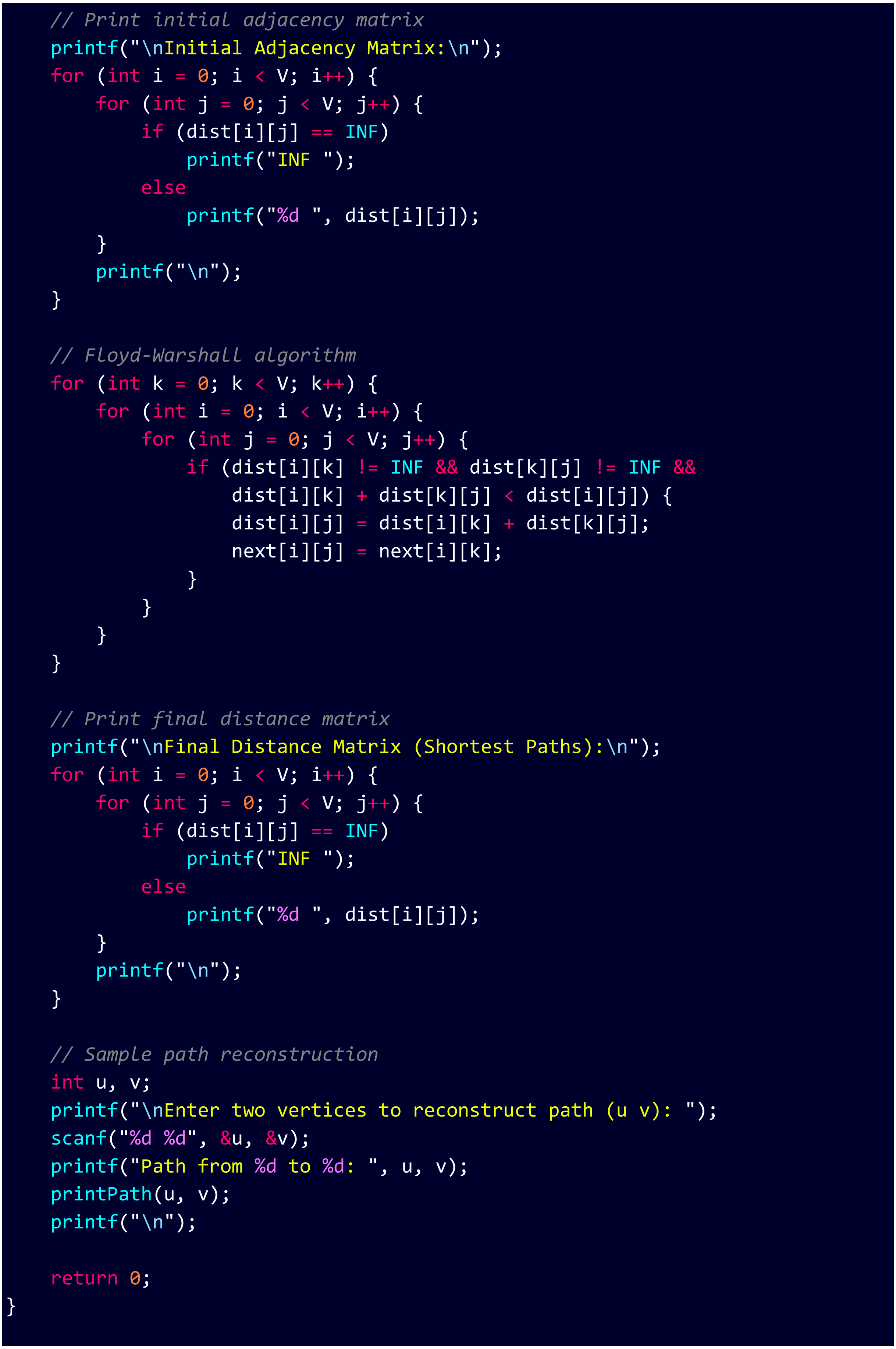


```
PS D:\pranjaltiwari029\DFS\graphs> g++ '.\prim''s.c'
PS D:\pranjaltiwari029\DFS\graphs> .\a.exe
Enter number of vertices and edges: 5 7
Enter edges (u v w):
0 1 2
0 3 6
1 2 3
1 3 8
1 4 5
2 4 7
3 4 9
Enter starting vertex: 0

Adjacency Matrix:
0 2 INF 6 INF
2 0 3 8 5
INF 3 0 INF 7
6 8 INF 0 9
INF 5 7 9 0

Edges in MST:
0 - 1 : 2
1 - 2 : 3
1 - 4 : 5
0 - 3 : 6

Total weight of MST: 16
```

Q22) Write a program in C to implement Floyd-Warshall Algorithm (All-pairs shortest path)

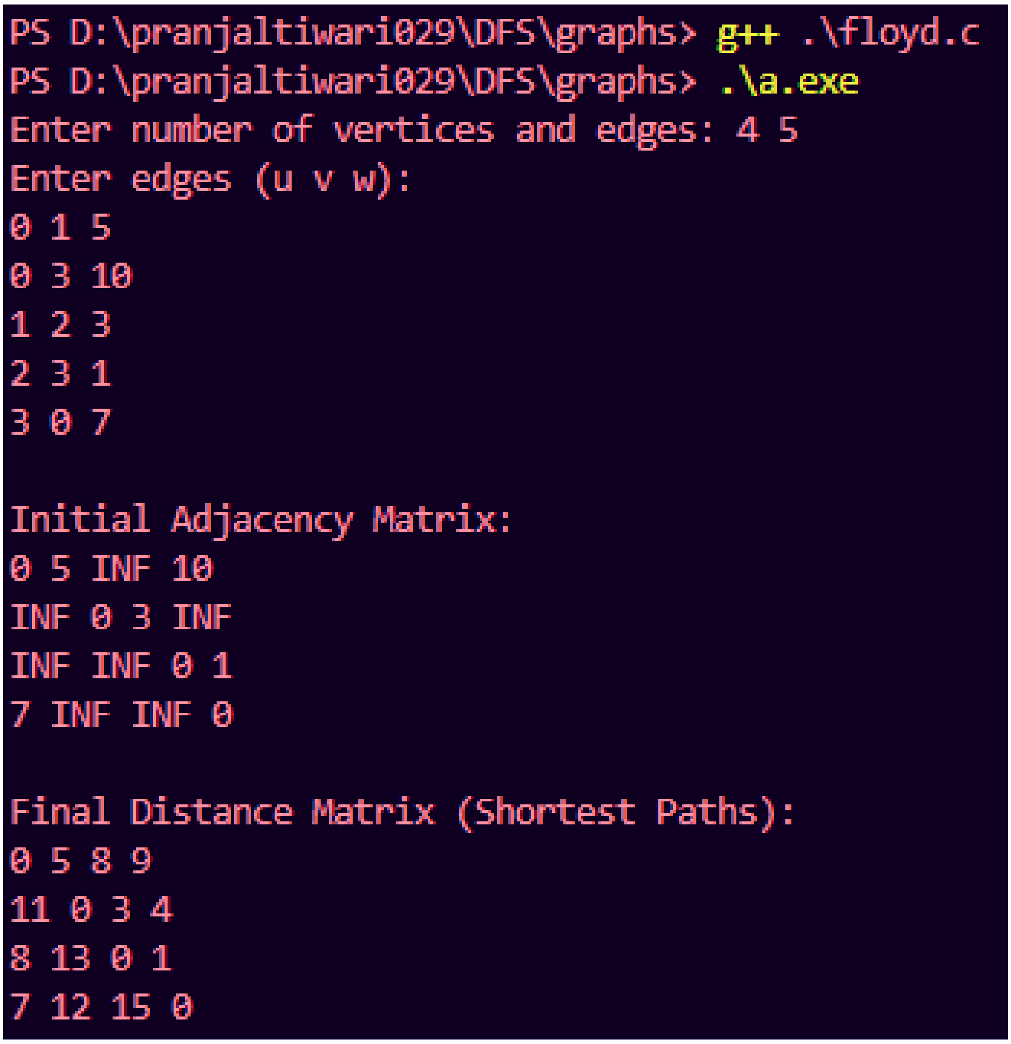
Code

```c
#include <stdio.h>

#define MAX 100
#define INF 99999

int dist[MAX][MAX];
int next[MAX][MAX]; // For path reconstruction

void printPath(int u, int v) {
    if (next[u][v] == -1) {
        printf("No path");
        return;
    }
    printf("%d", u);
    while (u != v) {
        u = next[u][v];
        printf(" -> %d", u);
    }
}

int main() {
    int V, E;
    printf("Enter number of vertices and edges: ");
    scanf("%d %d", &V, &E);

    // Initialize distance and next matrices
    for (int i = 0; i < V; i++) {
        for (int j = 0; j < V; j++) {
            if (i == j)
                dist[i][j] = 0;
            else
                dist[i][j] = INF;
            next[i][j] = -1;
        }
    }

    printf("Enter edges (u v w):\n");
    for (int i = 0; i < E; i++) {
        int u, v, w;
        scanf("%d %d %d", &u, &v, &w);
        dist[u][v] = w;
        next[u][v] = v;
    }
```



```c
    // Print initial adjacency matrix
    printf("\nInitial Adjacency Matrix:\n");
    for (int i = 0; i < V; i++) {
        for (int j = 0; j < V; j++) {
            if (dist[i][j] == INF)
                printf("INF ");
            else
                printf("%d ", dist[i][j]);
        }
        printf("\n");
    }

    // Floyd-Warshall algorithm
    for (int k = 0; k < V; k++) {
        for (int i = 0; i < V; i++) {
            for (int j = 0; j < V; j++) {
                if (dist[i][k] != INF && dist[k][j] != INF &&
                    dist[i][k] + dist[k][j] < dist[i][j]) {
                    dist[i][j] = dist[i][k] + dist[k][j];
                    next[i][j] = next[i][k];
                }
            }
        }
    }

    // Print final distance matrix
    printf("\nFinal Distance Matrix (Shortest Paths):\n");
    for (int i = 0; i < V; i++) {
        for (int j = 0; j < V; j++) {
            if (dist[i][j] == INF)
                printf("INF ");
            else
                printf("%d ", dist[i][j]);
        }
        printf("\n");
    }

    // Sample path reconstruction
    int u, v;
    printf("\nEnter two vertices to reconstruct path (u v): ");
    scanf("%d %d", &u, &v);
    printf("Path from %d to %d: ", u, v);
    printPath(u, v);
    printf("\n");

    return 0;
}
```

Output

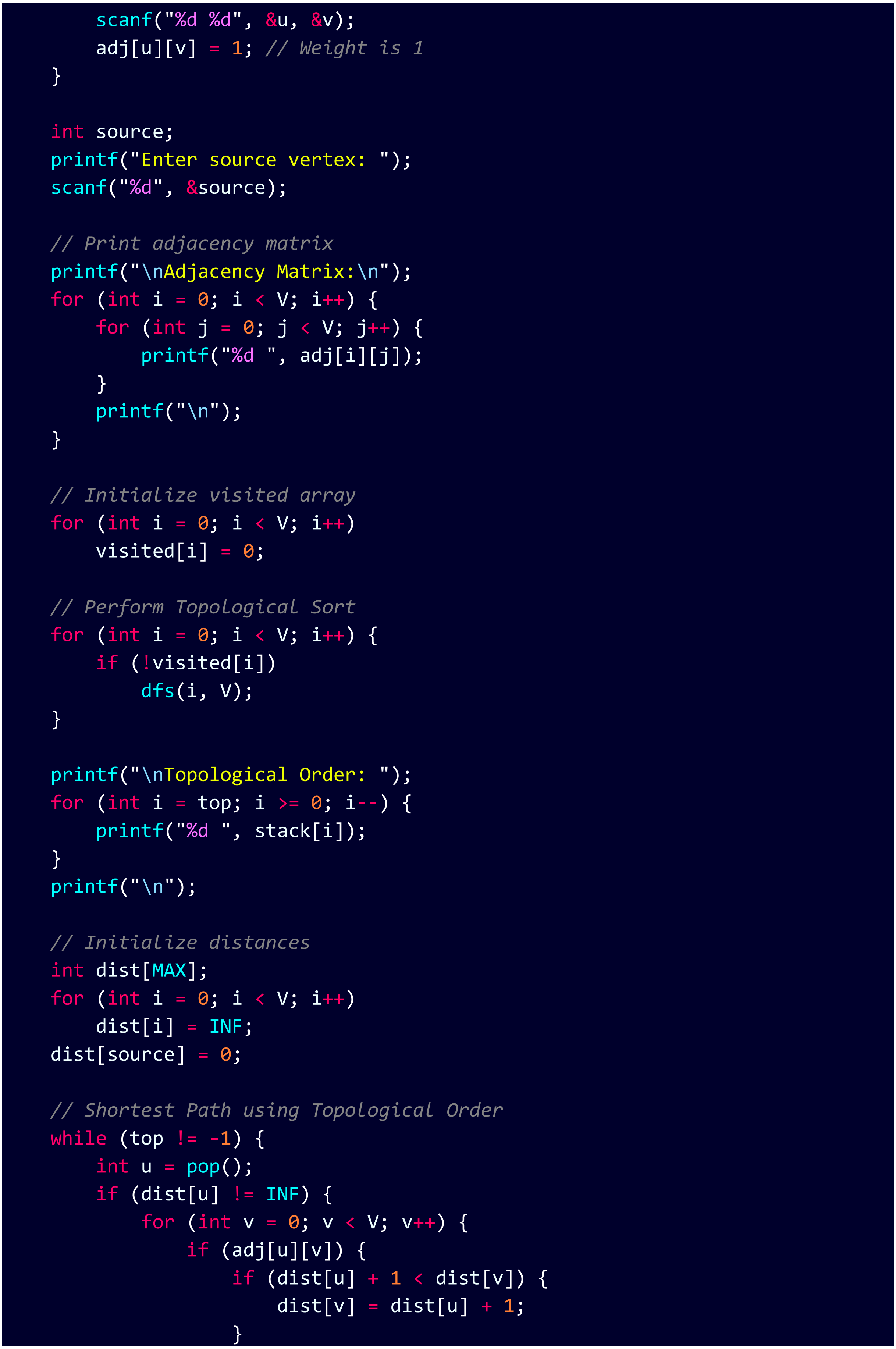


```
PS D:\pranjaltiwari029\DFS\graphs> g++ .\floyd.c
PS D:\pranjaltiwari029\DFS\graphs> .\a.exe
Enter number of vertices and edges: 4 5
Enter edges (u v w):
0 1 5
0 3 10
1 2 3
2 3 1
3 0 7

Initial Adjacency Matrix:
0 5 INF 10
INF 0 3 INF
INF INF 0 1
7 INF INF 0

Final Distance Matrix (Shortest Paths):
0 5 8 9
11 0 3 4
8 13 0 1
7 12 15 0
```

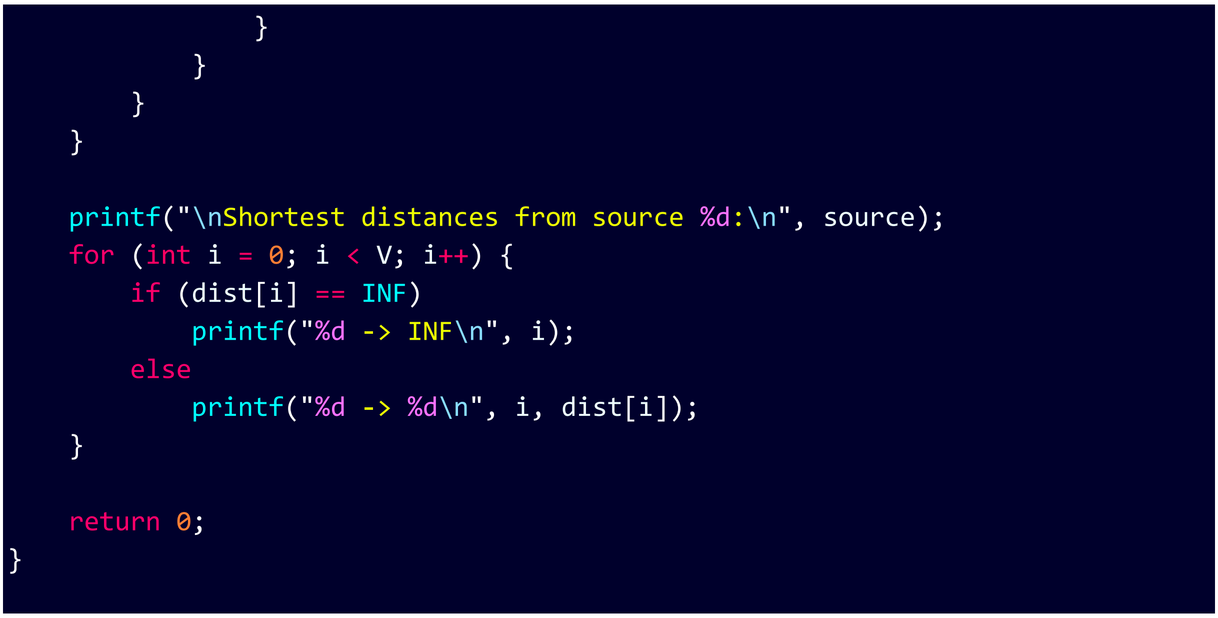
Q23) Write a program in C to implement Topological Sort & Shortest Path in DAG

Code

```
#include <stdio.h>
#include <stdlib.h>

#define MAX 100
#define INF 99999

int adj[MAX][MAX];
int visited[MAX];
int stack[MAX];
int top = -1;

// Push to stack
void push(int v) {
    stack[++top] = v;
}

// Pop from stack
int pop() {
    return stack[top--];
}

// Topological Sort (DFS based)
void dfs(int v, int V) {
    visited[v] = 1;
    for (int i = 0; i < V; i++) {
        if (adj[v][i] && !visited[i]) {
            dfs(i, V);
        }
    }
    push(v);
}

int main() {
    int V, E;
    printf("Enter number of vertices and edges: ");
    scanf("%d %d", &V, &E);

    // Initialize adjacency matrix
    for (int i = 0; i < V; i++)
        for (int j = 0; j < V; j++)
            adj[i][j] = 0;

    printf("Enter edges (u v):\n");
    for (int i = 0; i < E; i++) {
        int u, v;
```

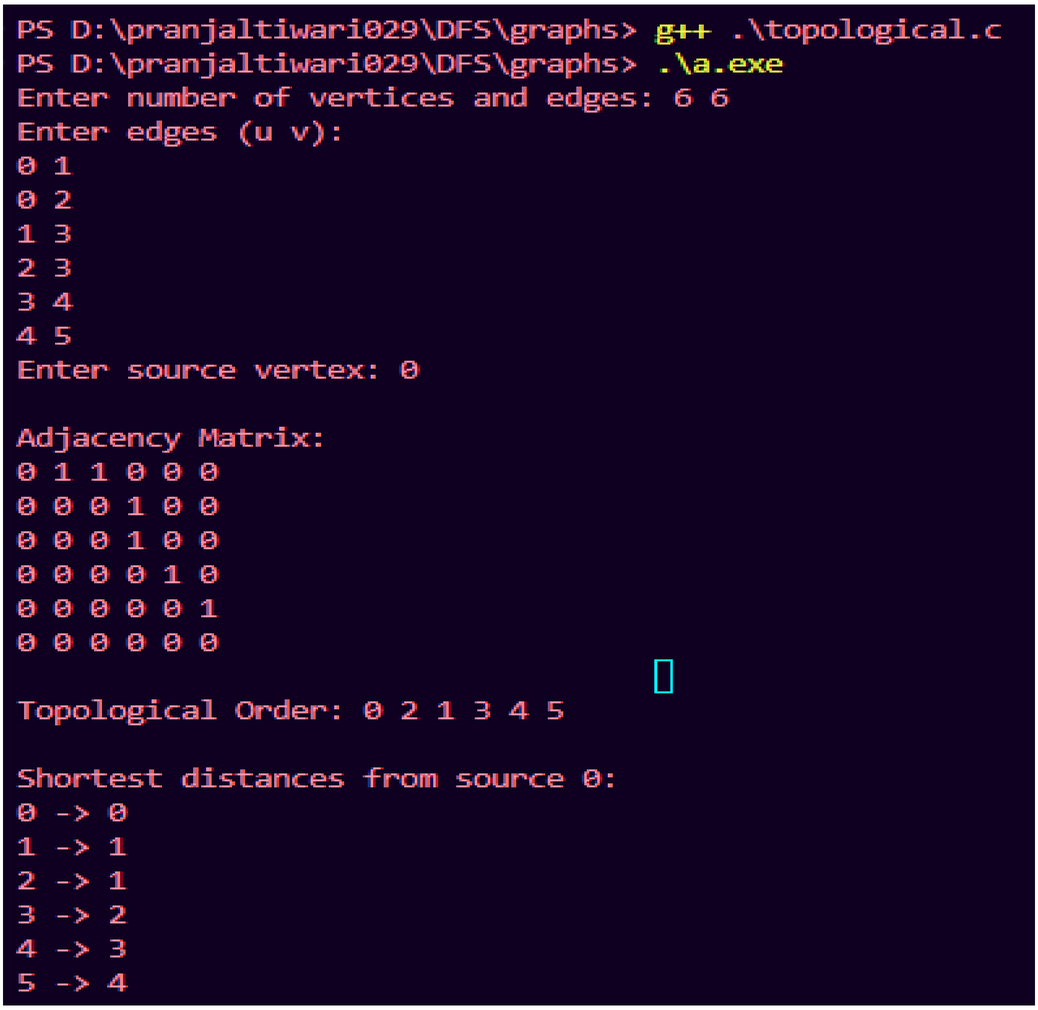


```
        scanf("%d %d", &u, &v);
        adj[u][v] = 1; // Weight is 1
    }

    int source;
    printf("Enter source vertex: ");
    scanf("%d", &source);

    // Print adjacency matrix
    printf("\nAdjacency Matrix:\n");
    for (int i = 0; i < V; i++) {
        for (int j = 0; j < V; j++) {
            printf("%d ", adj[i][j]);
        }
        printf("\n");
    }

    // Initialize visited array
    for (int i = 0; i < V; i++)
        visited[i] = 0;

    // Perform Topological Sort
    for (int i = 0; i < V; i++) {
        if (!visited[i])
            dfs(i, V);
    }

    printf("\nTopological Order: ");
    for (int i = top; i >= 0; i--) {
        printf("%d ", stack[i]);
    }
    printf("\n");

    // Initialize distances
    int dist[MAX];
    for (int i = 0; i < V; i++)
        dist[i] = INF;
    dist[source] = 0;

    // Shortest Path using Topological Order
    while (top != -1) {
        int u = pop();
        if (dist[u] != INF) {
            for (int v = 0; v < V; v++) {
                if (adj[u][v]) {
                    if (dist[u] + 1 < dist[v]) {
                        dist[v] = dist[u] + 1;
                    }
```



```
                }
            }
        }
    }

    printf("\nShortest distances from source %d:\n", source);
    for (int i = 0; i < V; i++) {
        if (dist[i] == INF)
            printf("%d -> INF\n", i);
        else
            printf("%d -> %d\n", i, dist[i]);
    }

    return 0;
}
```

Output

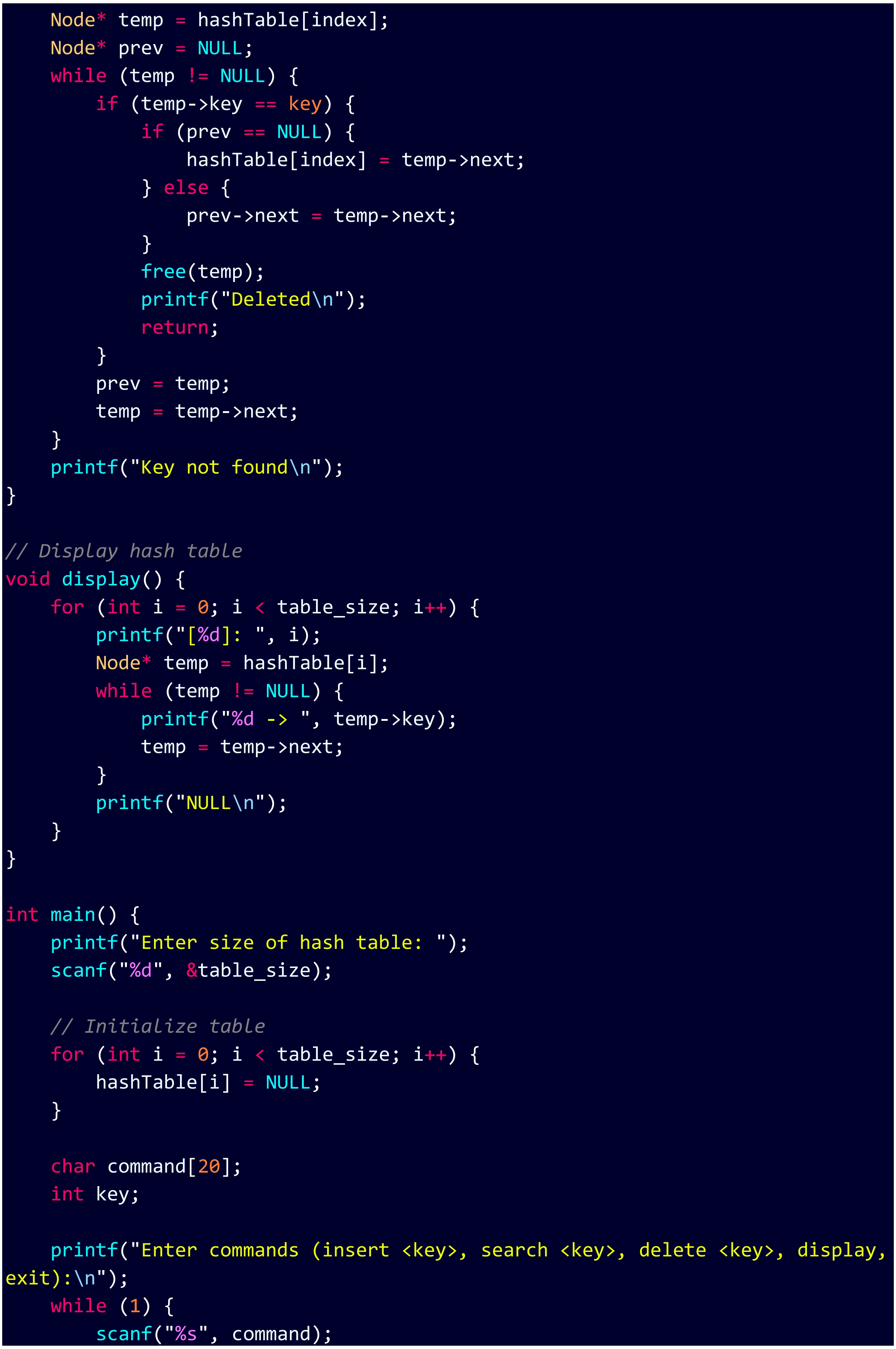


```
PS D:\pranjaltiwari029\DFS\graphs> g++ .\topological.c
PS D:\pranjaltiwari029\DFS\graphs> .\a.exe
Enter number of vertices and edges: 6 6
Enter edges (u v):
0 1
0 2
1 3
2 3
3 4
4 5
Enter source vertex: 0

Adjacency Matrix:
0 1 1 0 0 0
0 0 0 1 0 0
0 0 0 1 0 0
0 0 0 0 1 0
0 0 0 0 0 1
0 0 0 0 0 0

Topological Order: 0 2 1 3 4 5

Shortest distances from source 0:
0 -> 0
1 -> 1
2 -> 1
3 -> 2
4 -> 3
5 -> 4
```

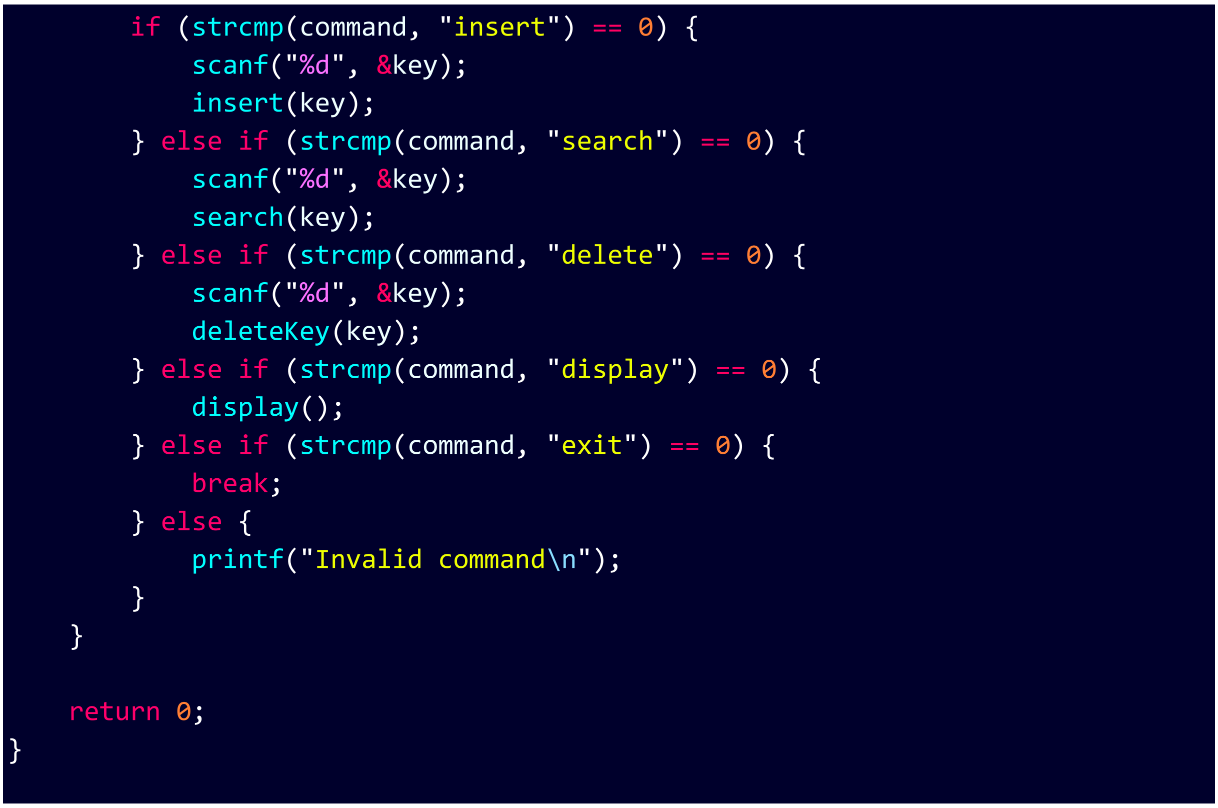
Q24) Write a program in C to implement Hash Table with Chaining

Code

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define MAX 100

typedef struct Node {
    int key;
    struct Node* next;
} Node;

Node* hashTable[MAX];
int table_size;

// Hash function
int hash(int key) {
    return key % table_size;
}

// Insert key
void insert(int key) {
    int index = hash(key);
    Node* newNode = (Node*)malloc(sizeof(Node));
    newNode->key = key;
    newNode->next = hashTable[index];
    hashTable[index] = newNode;
}

// Search key
void search(int key) {
    int index = hash(key);
    Node* temp = hashTable[index];
    while (temp != NULL) {
        if (temp->key == key) {
            printf("Found\n");
            return;
        }
        temp = temp->next;
    }
    printf("Not Found\n");
}

// Delete key
void deleteKey(int key) {
    int index = hash(key);
```

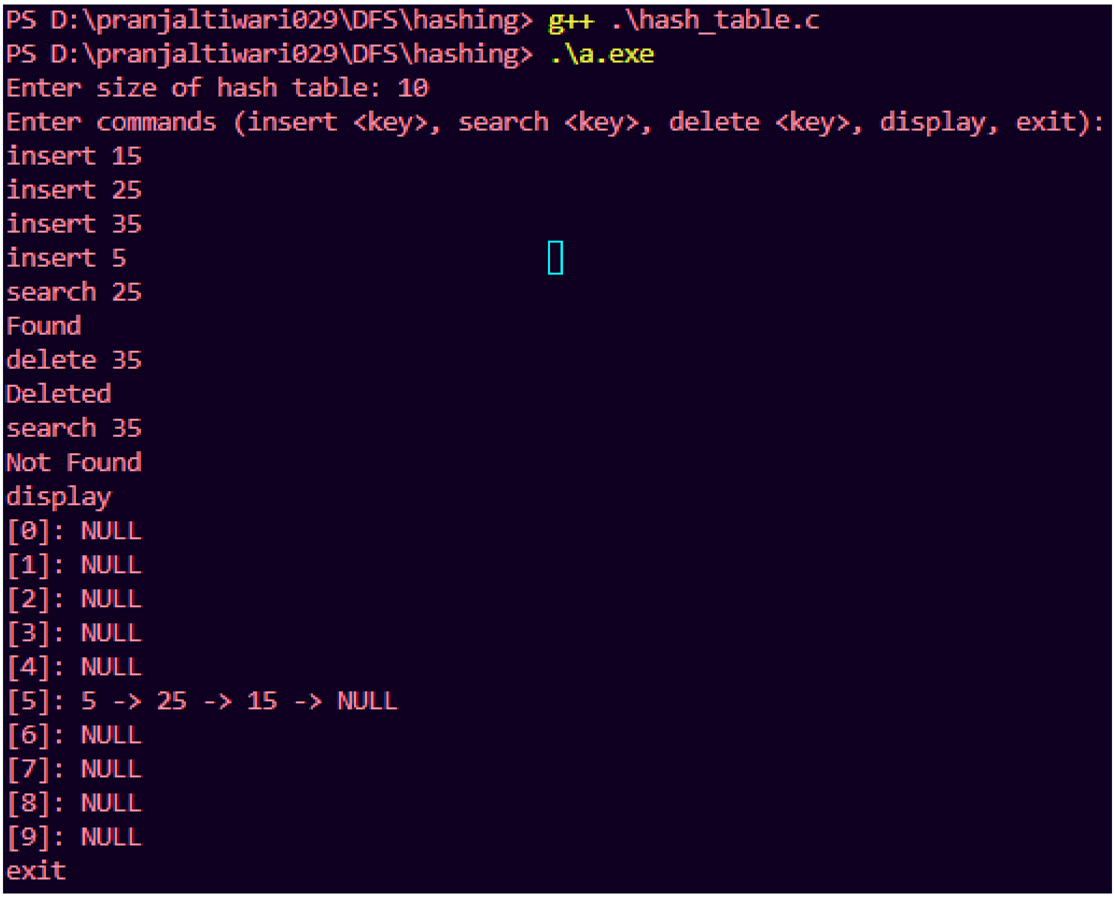


```
    Node* temp = hashTable[index];
    Node* prev = NULL;
    while (temp != NULL) {
        if (temp->key == key) {
            if (prev == NULL) {
                hashTable[index] = temp->next;
            } else {
                prev->next = temp->next;
            }
            free(temp);
            printf("Deleted\n");
            return;
        }
        prev = temp;
        temp = temp->next;
    }
    printf("Key not found\n");
}

// Display hash table
void display() {
    for (int i = 0; i < table_size; i++) {
        printf("[%d]: ", i);
        Node* temp = hashTable[i];
        while (temp != NULL) {
            printf("%d -> ", temp->key);
            temp = temp->next;
        }
        printf("NULL\n");
    }
}

int main() {
    printf("Enter size of hash table: ");
    scanf("%d", &table_size);

    // Initialize table
    for (int i = 0; i < table_size; i++) {
        hashTable[i] = NULL;
    }

    char command[20];
    int key;

    printf("Enter commands (insert <key>, search <key>, delete <key>, display,
exit):\n");
    while (1) {
        scanf("%s", command);
```



```
        if (strcmp(command, "insert") == 0) {
            scanf("%d", &key);
            insert(key);
        } else if (strcmp(command, "search") == 0) {
            scanf("%d", &key);
            search(key);
        } else if (strcmp(command, "delete") == 0) {
            scanf("%d", &key);
            deleteKey(key);
        } else if (strcmp(command, "display") == 0) {
            display();
        } else if (strcmp(command, "exit") == 0) {
            break;
        } else {
            printf("Invalid command\n");
        }
    }

    return 0;
}
```

Output

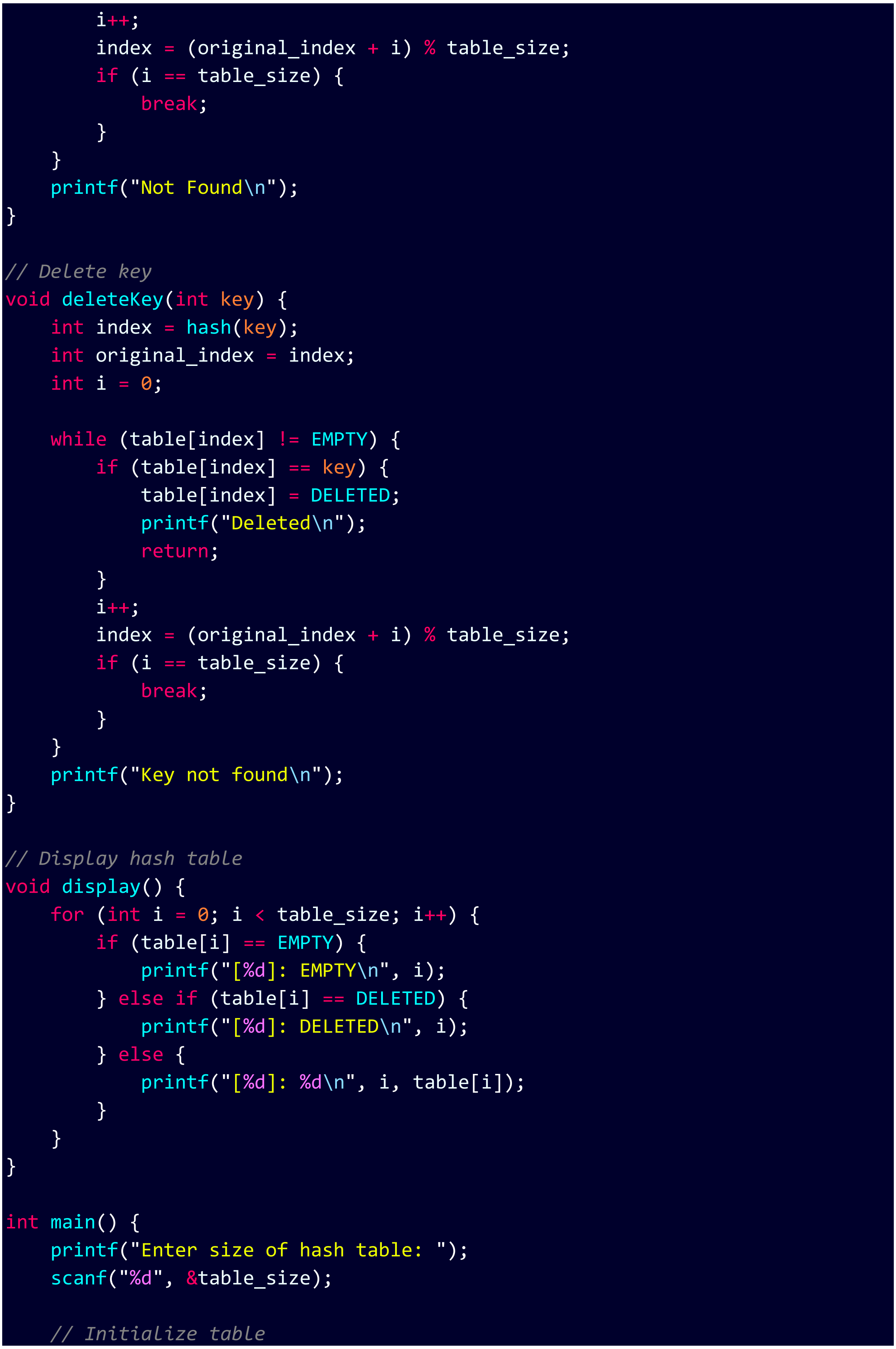


```
PS D:\pranjaltiwari029\DFS\hashing> g++ .\hash_table.c
PS D:\pranjaltiwari029\DFS\hashing> .\a.exe
Enter size of hash table: 10
Enter commands (insert <key>, search <key>, delete <key>, display, exit):
insert 15
insert 25
insert 35
insert 5
search 25
Found
delete 35
Deleted
search 35
Not Found
display
[0]: NULL
[1]: NULL
[2]: NULL
[3]: NULL
[4]: NULL
[5]: 5 -> 25 -> 15 -> NULL
[6]: NULL
[7]: NULL
[8]: NULL
[9]: NULL
exit
```

Q25) Write a program in C to implement Hash Table with Open Addressing (Linear Probing)

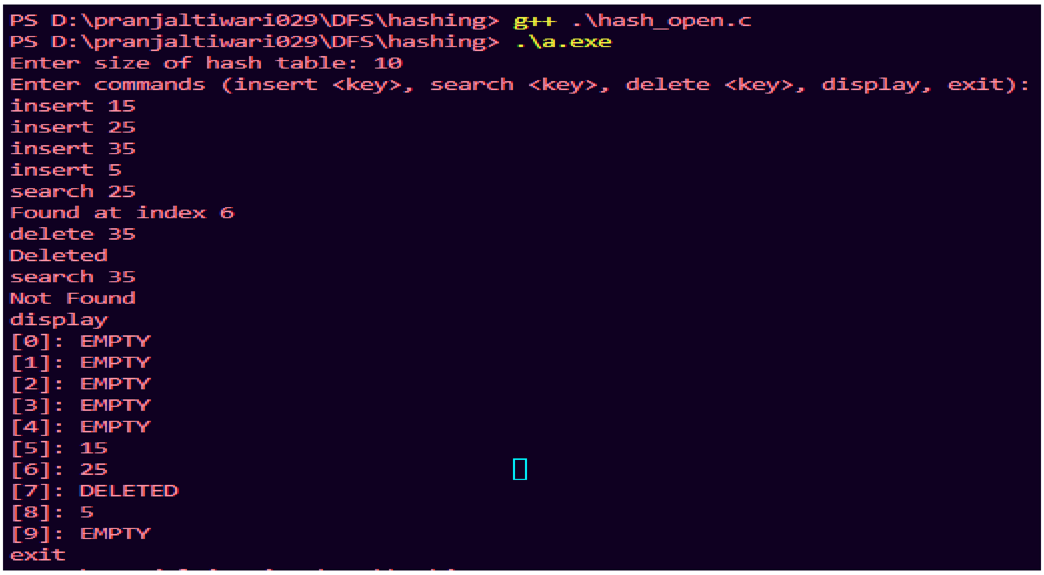
Code

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define MAX 100
#define EMPTY -1
#define DELETED -2

int table[MAX];
int table_size;

// Hash function
int hash(int key) {
    return key % table_size;
}

// Insert key
void insert(int key) {
    int index = hash(key);
    int original_index = index;
    int i = 0;

    while (table[index] != EMPTY && table[index] != DELETED) {
        i++;
        index = (original_index + i) % table_size;
        if (i == table_size) {
            printf("Hash Table is full! Cannot insert.\n");
            return;
        }
    }
    table[index] = key;
}

// Search key
void search(int key) {
    int index = hash(key);
    int original_index = index;
    int i = 0;

    while (table[index] != EMPTY) {
        if (table[index] == key) {
            printf("Found at index %d\n", index);
            return;
        }
```



```
        i++;
        index = (original_index + i) % table_size;
        if (i == table_size) {
            break;
        }
    }
    printf("Not Found\n");
}

// Delete key
void deleteKey(int key) {
    int index = hash(key);
    int original_index = index;
    int i = 0;

    while (table[index] != EMPTY) {
        if (table[index] == key) {
            table[index] = DELETED;
            printf("Deleted\n");
            return;
        }
        i++;
        index = (original_index + i) % table_size;
        if (i == table_size) {
            break;
        }
    }
    printf("Key not found\n");
}

// Display hash table
void display() {
    for (int i = 0; i < table_size; i++) {
        if (table[i] == EMPTY) {
            printf("[%d]: EMPTY\n", i);
        } else if (table[i] == DELETED) {
            printf("[%d]: DELETED\n", i);
        } else {
            printf("[%d]: %d\n", i, table[i]);
        }
    }
}

int main() {
    printf("Enter size of hash table: ");
    scanf("%d", &table_size);

    // Initialize table
    for (int i = 0; i < table_size; i++) {
        table[i] = EMPTY;
    }

    char command[20];
    int key;

    printf("Enter commands (insert <key>, search <key>, delete <key>, display,
exit):\n");
    while (1) {
        scanf("%s", command);
        if (strcmp(command, "insert") == 0) {
            scanf("%d", &key);
            insert(key);
        } else if (strcmp(command, "search") == 0) {
            scanf("%d", &key);
            search(key);
        } else if (strcmp(command, "delete") == 0) {
            scanf("%d", &key);
            deleteKey(key);
        } else if (strcmp(command, "display") == 0) {
            display();
        } else if (strcmp(command, "exit") == 0) {
            break;
        } else {
            printf("Invalid command\n");
        }
    }

    return 0;
}
```

Output

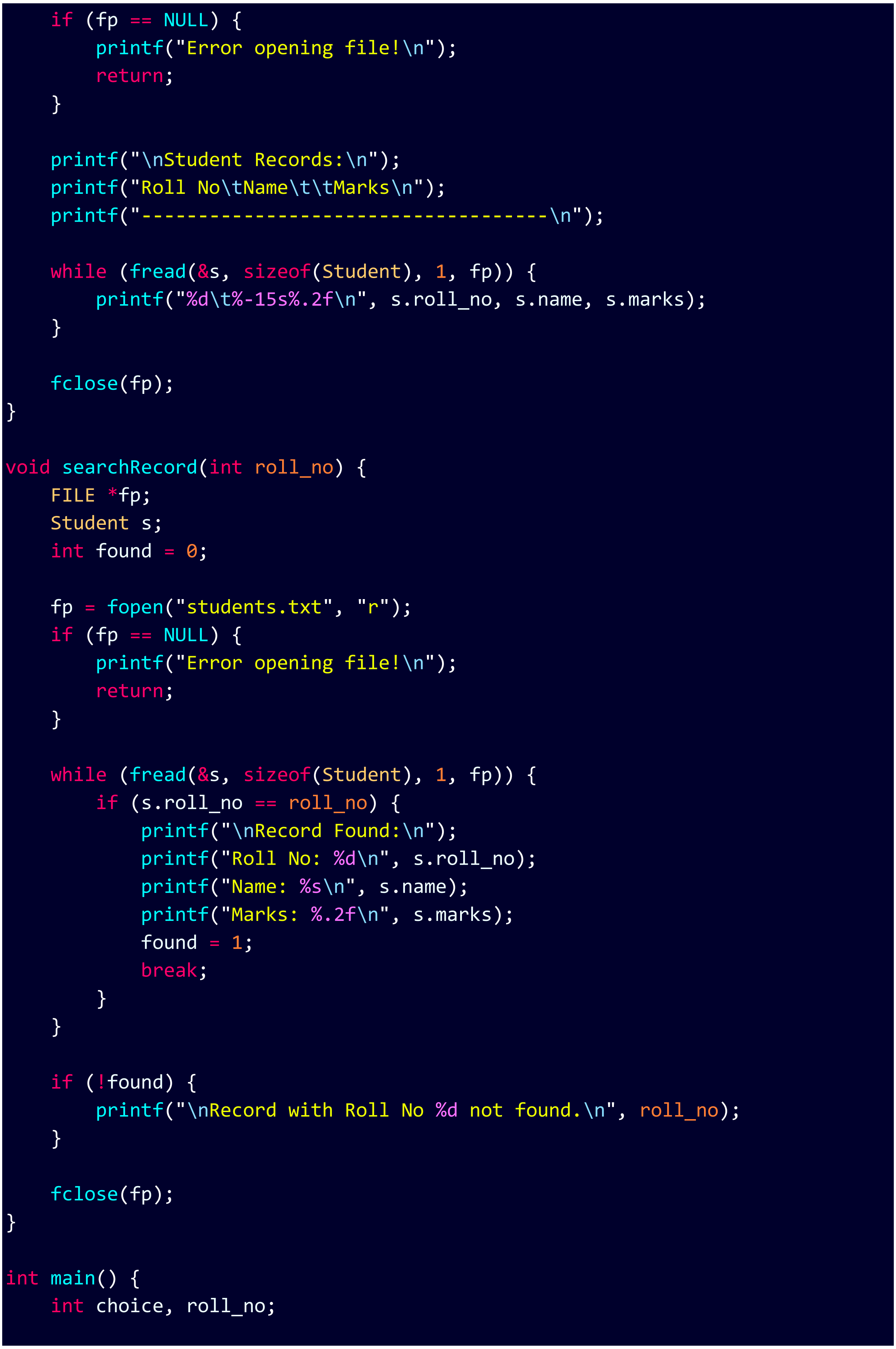


```
PS D:\pranjaltiwari029\DFS\hashing> g++ .\hash_open.c
PS D:\pranjaltiwari029\DFS\hashing> .\a.exe
Enter size of hash table: 10
Enter commands (insert <key>, search <key>, delete <key>, display, exit):
insert 15
insert 25
insert 35
insert 5
search 25
Found at index 6
delete 35
Deleted
search 35
Not Found
display
[0]: EMPTY
[1]: EMPTY
[2]: EMPTY
[3]: EMPTY
[4]: EMPTY
[5]: 15
[6]: 25
[7]: DELETED
[8]: 5
[9]: EMPTY
exit
```

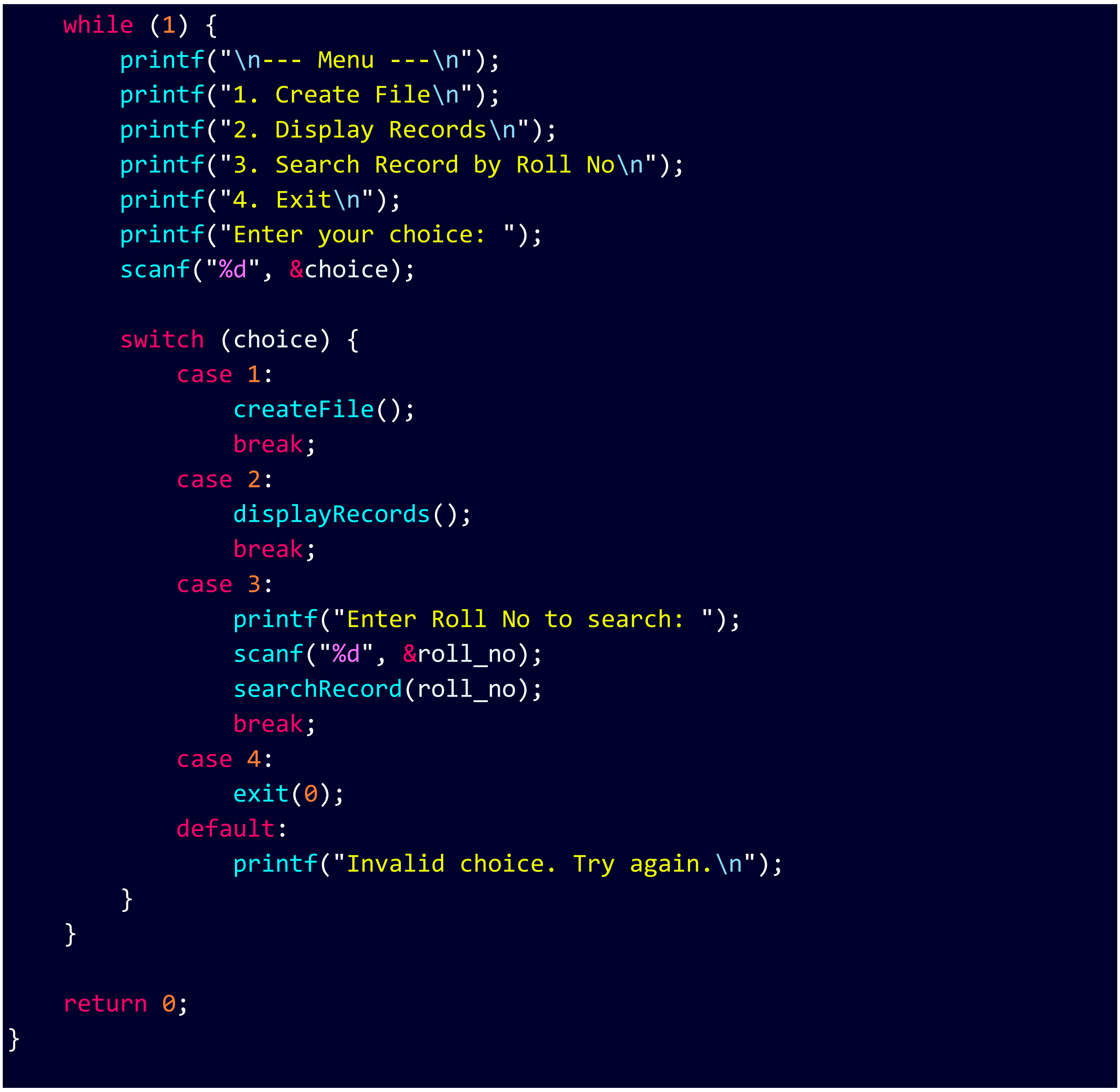
Q26) Write a program in C to implement Sequential File Handling in C (Student Records)

Code

```c
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

typedef struct {
    int roll_no;
    char name[50];
    float marks;
} Student;

void createFile() {
    FILE *fp;
    Student s;
    int n;

    fp = fopen("students.txt", "w");
    if (fp == NULL) {
        printf("Error creating file!\n");
        return;
    }

    printf("Enter number of students: ");
    scanf("%d", &n);

    for (int i = 0; i < n; i++) {
        printf("Enter details for student %d\n", i + 1);
        printf("Roll No: ");
        scanf("%d", &s.roll_no);
        printf("Name: ");
        scanf(" %[^\n]", s.name);  // to read full line including spaces
        printf("Marks: ");
        scanf("%f", &s.marks);

        fwrite(&s, sizeof(Student), 1, fp);
    }

    fclose(fp);
    printf("File created successfully!\n");
}

void displayRecords() {
    FILE *fp;
    Student s;

    fp = fopen("students.txt", "r");
```

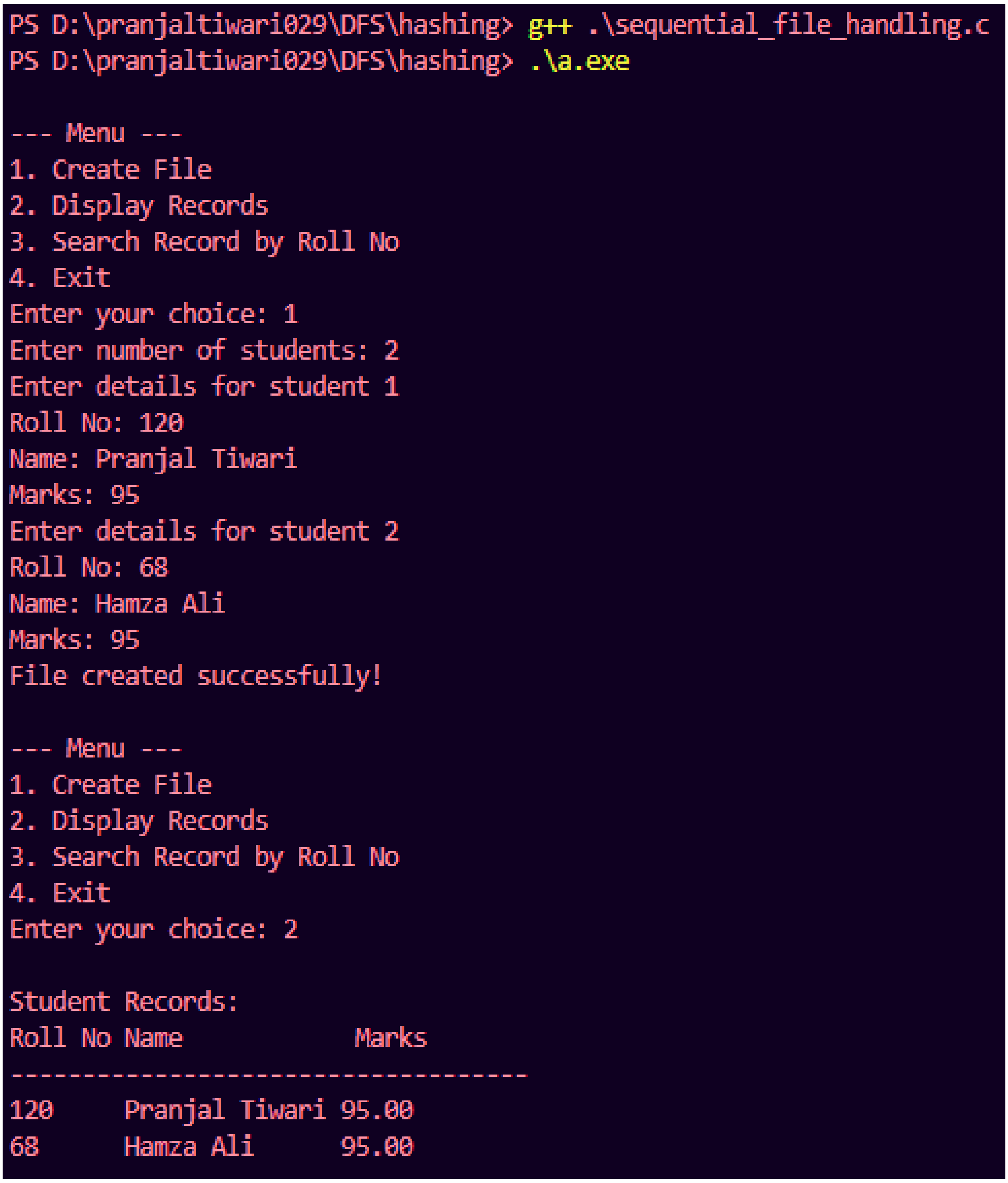


```c
    if (fp == NULL) {
        printf("Error opening file!\n");
        return;
    }

    printf("\nStudent Records:\n");
    printf("Roll No\tName\t\tMarks\n");
    printf("------------------------------------\n");

    while (fread(&s, sizeof(Student), 1, fp)) {
        printf("%d\t%-15s%.2f\n", s.roll_no, s.name, s.marks);
    }

    fclose(fp);
}

void searchRecord(int roll_no) {
    FILE *fp;
    Student s;
    int found = 0;

    fp = fopen("students.txt", "r");
    if (fp == NULL) {
        printf("Error opening file!\n");
        return;
    }

    while (fread(&s, sizeof(Student), 1, fp)) {
        if (s.roll_no == roll_no) {
            printf("\nRecord Found:\n");
            printf("Roll No: %d\n", s.roll_no);
            printf("Name: %s\n", s.name);
            printf("Marks: %.2f\n", s.marks);
            found = 1;
            break;
        }
    }

    if (!found) {
        printf("\nRecord with Roll No %d not found.\n", roll_no);
    }

    fclose(fp);
}

int main() {
    int choice, roll_no;
```



```c
    while (1) {
        printf("\n--- Menu ---\n");
        printf("1. Create File\n");
        printf("2. Display Records\n");
        printf("3. Search Record by Roll No\n");
        printf("4. Exit\n");
        printf("Enter your choice: ");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                createFile();
                break;
            case 2:
                displayRecords();
                break;
            case 3:
                printf("Enter Roll No to search: ");
                scanf("%d", &roll_no);
                searchRecord(roll_no);
                break;
            case 4:
                exit(0);
            default:
                printf("Invalid choice. Try again.\n");
        }
    }

    return 0;
}
```

Output

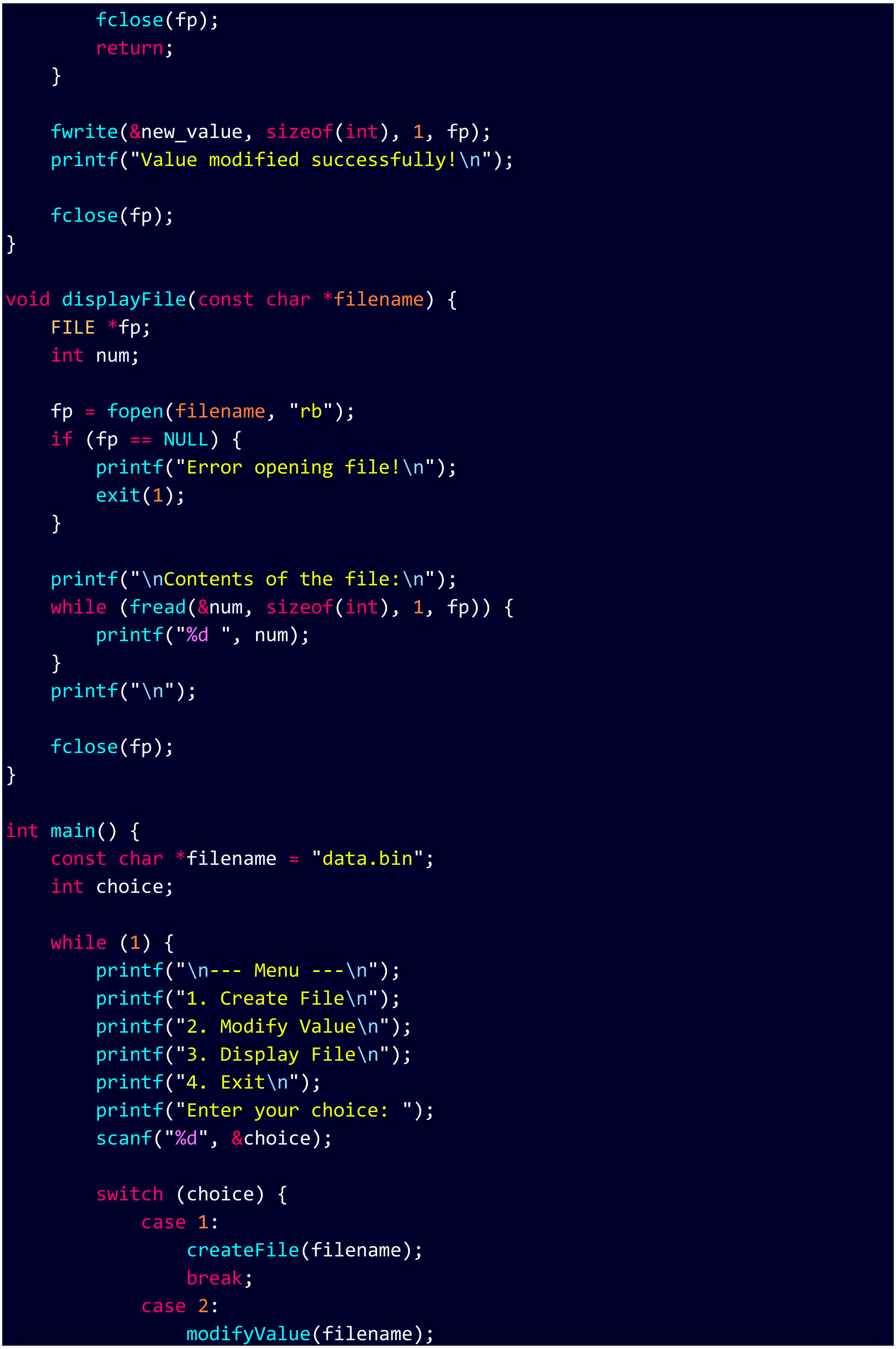


```
PS D:\pranjaltiwari029\DFS\hashing> g++ .\sequential_file_handling.c
PS D:\pranjaltiwari029\DFS\hashing> .\a.exe

--- Menu ---
1. Create File
2. Display Records
3. Search Record by Roll No
4. Exit
Enter your choice: 1
Enter number of students: 2
Enter details for student 1
Roll No: 120
Name: Pranjal Tiwari
Marks: 95
Enter details for student 2
Roll No: 68
Name: Hamza Ali
Marks: 95
File created successfully!

--- Menu ---
1. Create File
2. Display Records
3. Search Record by Roll No
4. Exit
Enter your choice: 2

Student Records:
Roll No Name            Marks
------------------------------------
120     Pranjal Tiwari 95.00
68      Hamza Ali      95.00
```

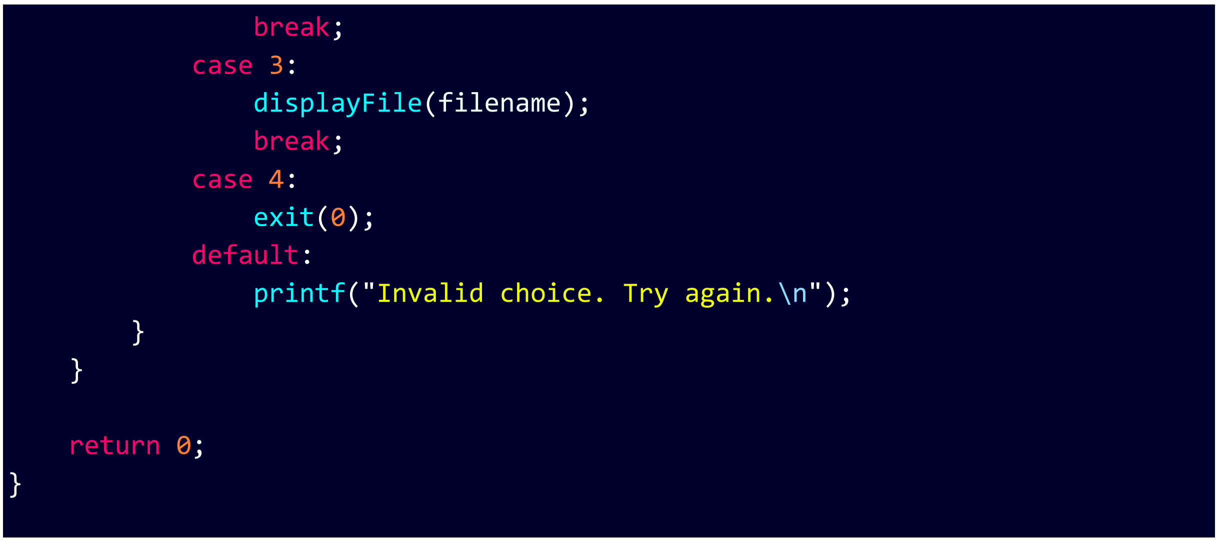
Q27) Write a program in C to implement Binary File Operations in C (Seek/Read/Write)

Code

```c
#include <stdio.h>
#include <stdlib.h>

void createFile(const char *filename) {
    FILE *fp;
    int n, num;

    fp = fopen(filename, "wb");
    if (fp == NULL) {
        printf("Error creating file!\n");
        exit(1);
    }

    printf("Enter number of integers: ");
    scanf("%d", &n);

    printf("Enter %d integers:\n", n);
    for (int i = 0; i < n; i++) {
        scanf("%d", &num);
        fwrite(&num, sizeof(int), 1, fp);
    }

    fclose(fp);
    printf("File created successfully!\n");
}

void modifyValue(const char *filename) {
    FILE *fp;
    int index, new_value;
    long offset;

    fp = fopen(filename, "rb+"); // open for read and write
    if (fp == NULL) {
        printf("Error opening file!\n");
        exit(1);
    }

    printf("Enter index to modify (starting from 0): ");
    scanf("%d", &index);
    printf("Enter new value: ");
    scanf("%d", &new_value);

    offset = index * sizeof(int);
    if (fseek(fp, offset, SEEK_SET) != 0) {
        printf("Error seeking to position!\n");
```

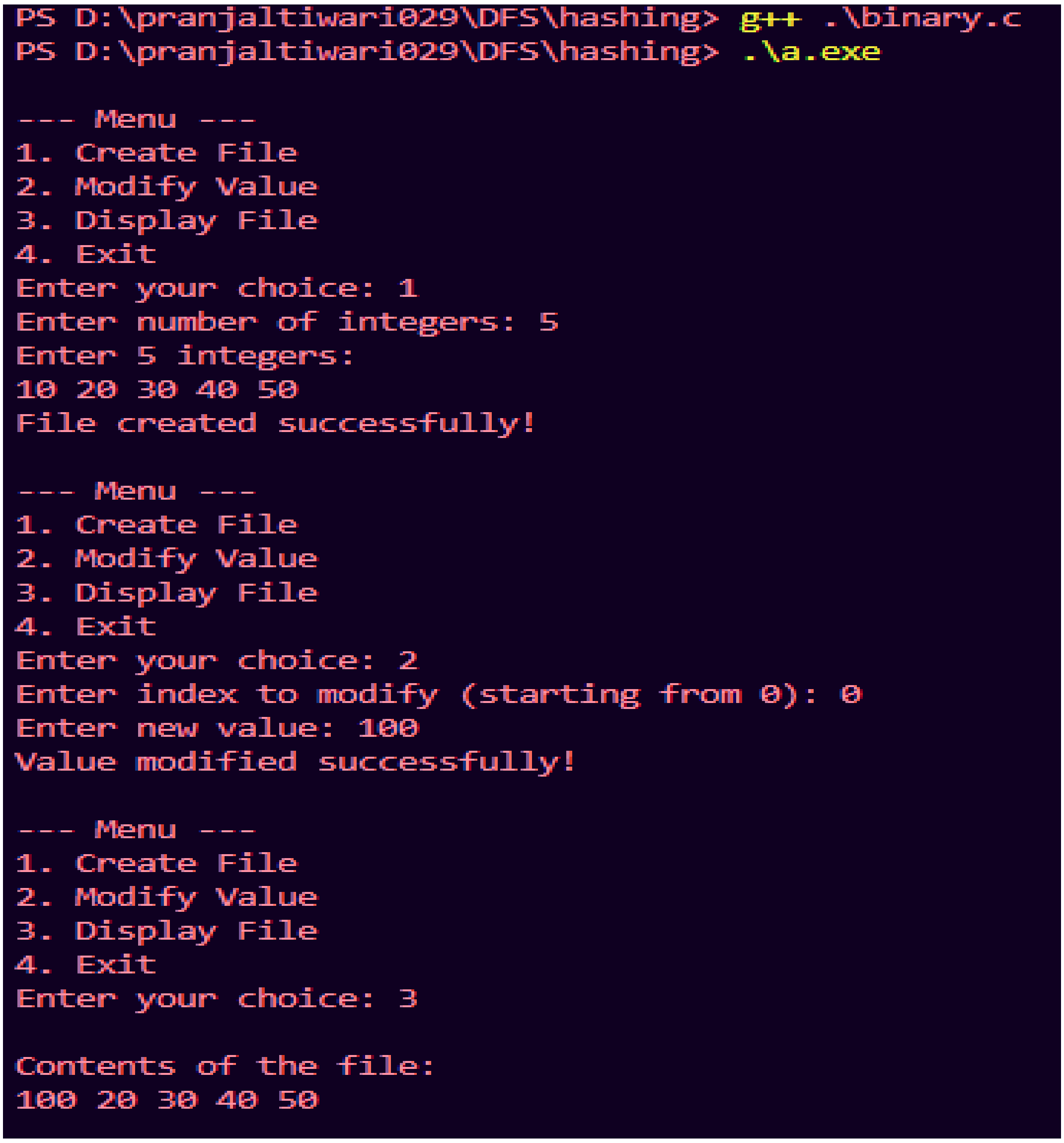


```
        fclose(fp);
        return;
    }

    fwrite(&new_value, sizeof(int), 1, fp);
    printf("Value modified successfully!\n");

    fclose(fp);
}

void displayFile(const char *filename) {
    FILE *fp;
    int num;

    fp = fopen(filename, "rb");
    if (fp == NULL) {
        printf("Error opening file!\n");
        exit(1);
    }

    printf("\nContents of the file:\n");
    while (fread(&num, sizeof(int), 1, fp)) {
        printf("%d ", num);
    }
    printf("\n");

    fclose(fp);
}

int main() {
    const char *filename = "data.bin";
    int choice;

    while (1) {
        printf("\n--- Menu ---\n");
        printf("1. Create File\n");
        printf("2. Modify Value\n");
        printf("3. Display File\n");
        printf("4. Exit\n");
        printf("Enter your choice: ");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                createFile(filename);
                break;
            case 2:
                modifyValue(filename);
```



```
                break;
            case 3:
                displayFile(filename);
                break;
            case 4:
                exit(0);
            default:
                printf("Invalid choice. Try again.\n");
        }
    }

    return 0;
}
```

Output



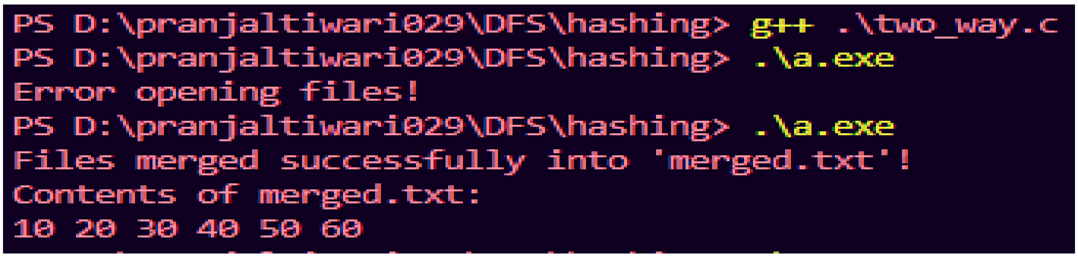
```
PS D:\pranjaltiwari029\DFS\hashing> g++ .\binary.c
PS D:\pranjaltiwari029\DFS\hashing> .\a.exe

--- Menu ---
1. Create File
2. Modify Value
3. Display File
4. Exit
Enter your choice: 1
Enter number of integers: 5
Enter 5 integers:
10 20 30 40 50
File created successfully!

--- Menu ---
1. Create File
2. Modify Value
3. Display File
4. Exit
Enter your choice: 2
Enter index to modify (starting from 0): 0
Enter new value: 100
Value modified successfully!

--- Menu ---
1. Create File
2. Modify Value
3. Display File
4. Exit
Enter your choice: 3

Contents of the file:
100 20 30 40 50
```

Q28) Write a program in C to implement Two-Way Merge for External Sorting

Code

```
#include <stdio.h>
#include <stdlib.h>

void mergeFiles(const char *file1, const char *file2, const char *mergedFile)
{
    FILE *f1, *f2, *fout;
    int num1, num2;
    int end1 = 0, end2 = 0;

    f1 = fopen(file1, "r");
    f2 = fopen(file2, "r");
    fout = fopen(mergedFile, "w");

    if (f1 == NULL || f2 == NULL || fout == NULL) {
        printf("Error opening files!\n");
        exit(1);
    }

    // Read first numbers from both files
    if (fscanf(f1, "%d", &num1) != 1) end1 = 1;
    if (fscanf(f2, "%d", &num2) != 1) end2 = 1;

    // Merge process
    while (!end1 && !end2) {
        if (num1 <= num2) {
            fprintf(fout, "%d ", num1);
            if (fscanf(f1, "%d", &num1) != 1) end1 = 1;
        } else {
            fprintf(fout, "%d ", num2);
            if (fscanf(f2, "%d", &num2) != 1) end2 = 1;
        }
    }

    // Write remaining numbers from file1
    while (!end1) {
        fprintf(fout, "%d ", num1);
        if (fscanf(f1, "%d", &num1) != 1) end1 = 1;
    }

    // Write remaining numbers from file2
    while (!end2) {
        fprintf(fout, "%d ", num2);
        if (fscanf(f2, "%d", &num2) != 1) end2 = 1;
    }
    printf("Files merged successfully into '%s'!\n", mergedFile);

    fclose(f1);
    fclose(f2);
    fclose(fout);
}

void displayFile(const char *filename) {
    FILE *fp;
    int num;

    fp = fopen(filename, "r");
    if (fp == NULL) {
        printf("Error opening file %s\n", filename);
        return;
    }

    printf("Contents of %s:\n", filename);
    while (fscanf(fp, "%d", &num) == 1) {
        printf("%d ", num);
    }
    printf("\n");

    fclose(fp);
}

int main() {
    const char *file1 = "file1.txt";
    const char *file2 = "file2.txt";
    const char *mergedFile = "merged.txt";

    mergeFiles(file1, file2, mergedFile);
    displayFile(mergedFile);

    return 0;
}
```

Output

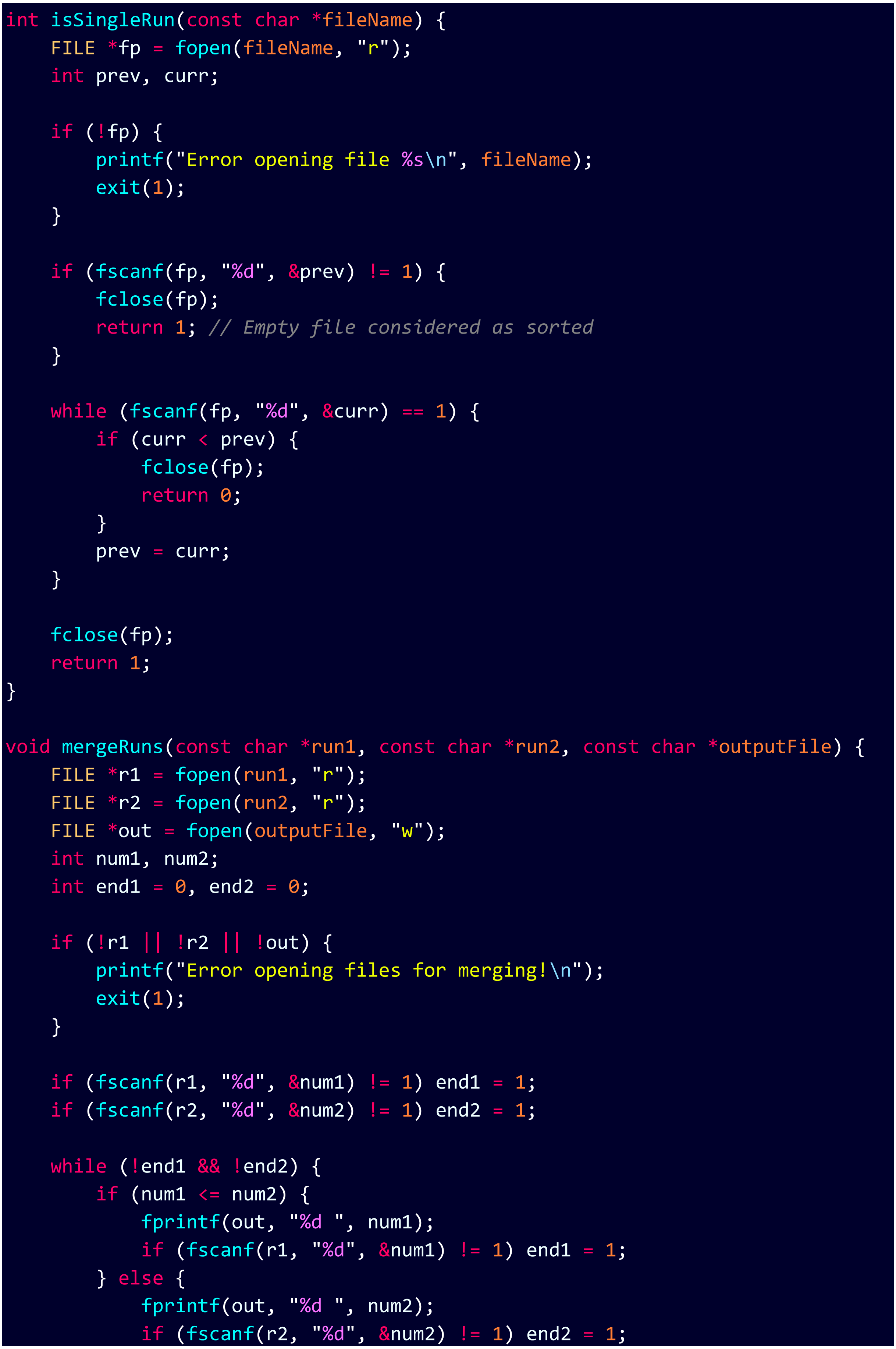


```
PS D:\pranjaltiwari029\DFS\hashing> g++ .\two_way.c
PS D:\pranjaltiwari029\DFS\hashing> .\a.exe
Error opening files!
PS D:\pranjaltiwari029\DFS\hashing> .\a.exe
Files merged successfully into 'merged.txt'!
Contents of merged.txt:
10 20 30 40 50 60
```

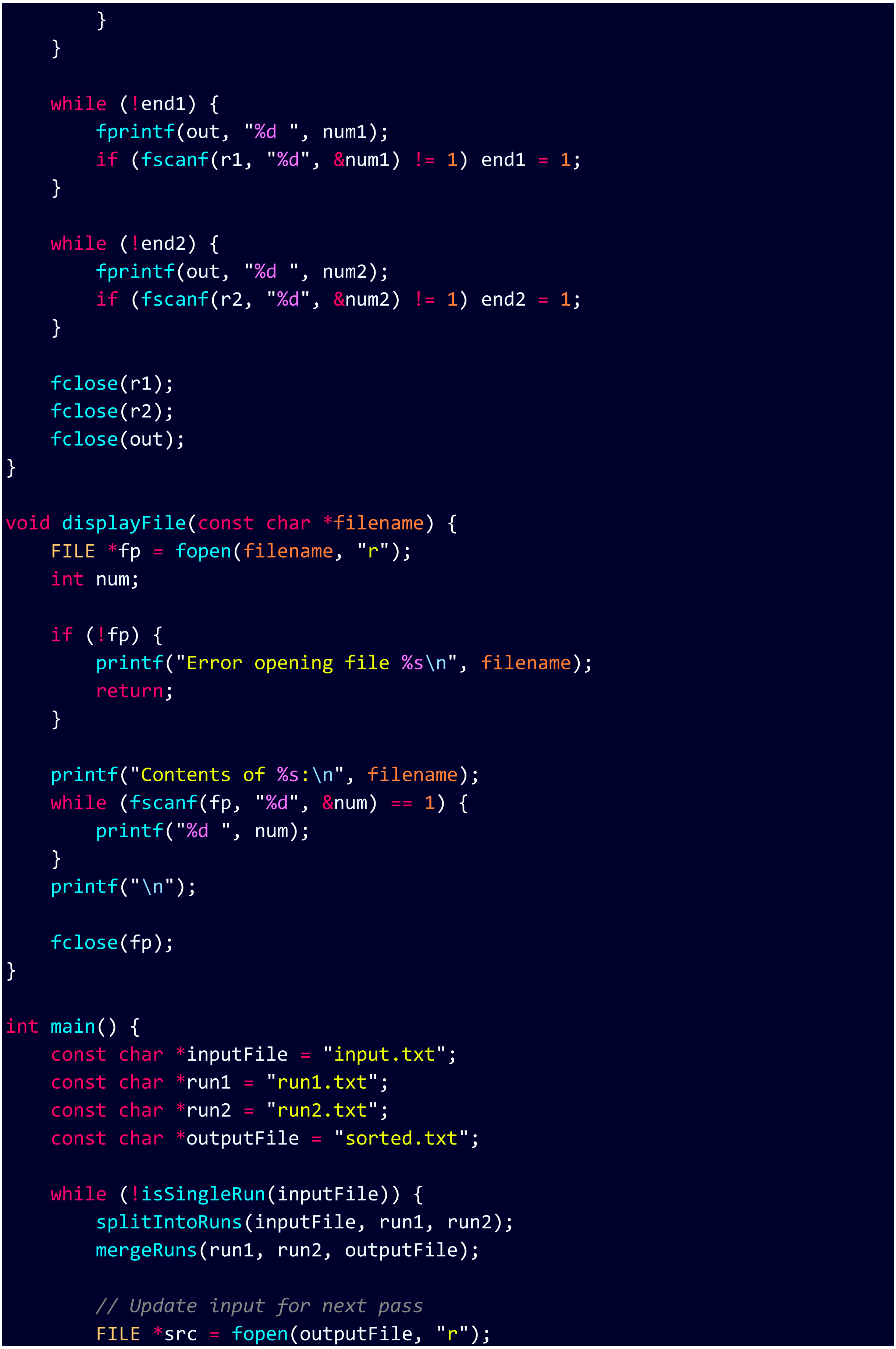
Q29) Write a program in C to implement Natural Merge Sort on Files

Code

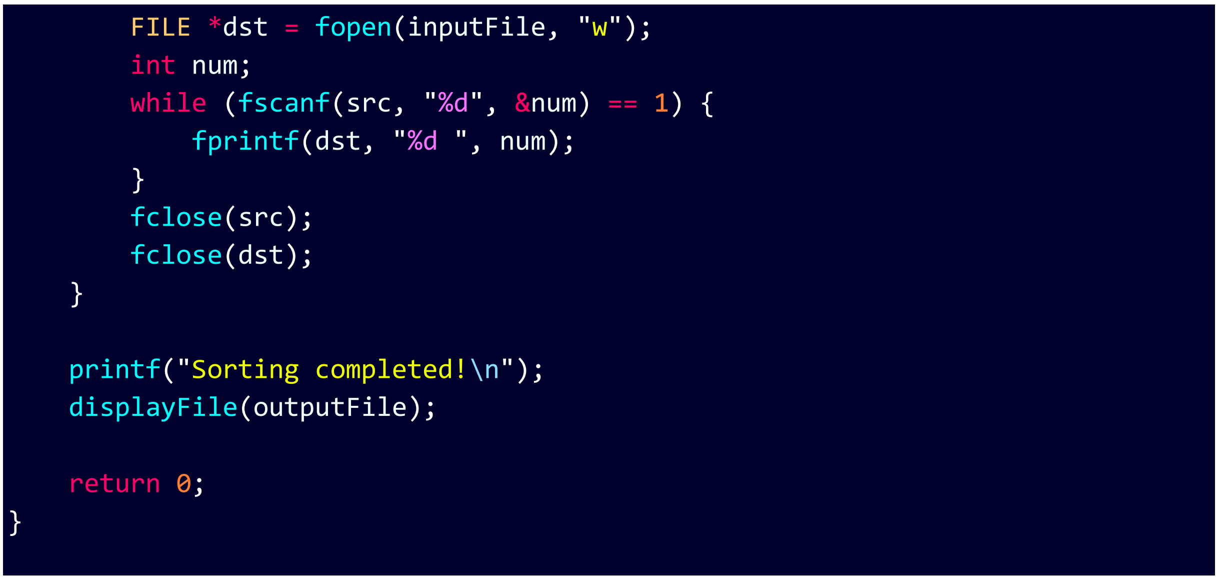
```c
#include <stdio.h>
#include <stdlib.h>

#define MAX 1000

void splitIntoRuns(const char *inputFile, const char *run1, const char *run2)
{
    FILE *in = fopen(inputFile, "r");
    FILE *r1 = fopen(run1, "w");
    FILE *r2 = fopen(run2, "w");
    int prev, curr;
    int toggle = 0;

    if (!in || !r1 || !r2) {
        printf("Error opening files!\n");
        exit(1);
    }

    if (fscanf(in, "%d", &prev) != 1) {
        fclose(in);
        fclose(r1);
        fclose(r2);
        return;
    }

    fprintf(r1, "%d ", prev);

    while (fscanf(in, "%d", &curr) == 1) {
        if (curr < prev) {
            toggle = 1 - toggle; // Switch files
        }

        if (toggle == 0)
            fprintf(r1, "%d ", curr);
        else
            fprintf(r2, "%d ", curr);

        prev = curr;
    }

    fclose(in);
    fclose(r1);
    fclose(r2);
}
```



```c
int isSingleRun(const char *fileName) {
    FILE *fp = fopen(fileName, "r");
    int prev, curr;

    if (!fp) {
        printf("Error opening file %s\n", fileName);
        exit(1);
    }

    if (fscanf(fp, "%d", &prev) != 1) {
        fclose(fp);
        return 1; // Empty file considered as sorted
    }

    while (fscanf(fp, "%d", &curr) == 1) {
        if (curr < prev) {
            fclose(fp);
            return 0;
        }
        prev = curr;
    }

    fclose(fp);
    return 1;
}

void mergeRuns(const char *run1, const char *run2, const char *outputFile) {
    FILE *r1 = fopen(run1, "r");
    FILE *r2 = fopen(run2, "r");
    FILE *out = fopen(outputFile, "w");
    int num1, num2;
    int end1 = 0, end2 = 0;

    if (!r1 || !r2 || !out) {
        printf("Error opening files for merging!\n");
        exit(1);
    }

    if (fscanf(r1, "%d", &num1) != 1) end1 = 1;
    if (fscanf(r2, "%d", &num2) != 1) end2 = 1;

    while (!end1 && !end2) {
        if (num1 <= num2) {
            fprintf(out, "%d ", num1);
            if (fscanf(r1, "%d", &num1) != 1) end1 = 1;
        } else {
            fprintf(out, "%d ", num2);
            if (fscanf(r2, "%d", &num2) != 1) end2 = 1;
```

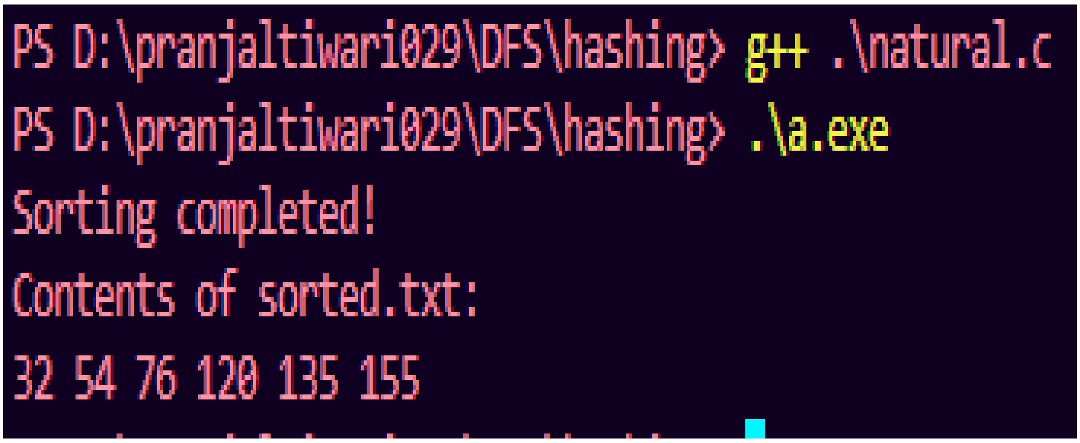


```
        }
    }

    while (!end1) {
        fprintf(out, "%d ", num1);
        if (fscanf(r1, "%d", &num1) != 1) end1 = 1;
    }

    while (!end2) {
        fprintf(out, "%d ", num2);
        if (fscanf(r2, "%d", &num2) != 1) end2 = 1;
    }

    fclose(r1);
    fclose(r2);
    fclose(out);
}

void displayFile(const char *filename) {
    FILE *fp = fopen(filename, "r");
    int num;

    if (!fp) {
        printf("Error opening file %s\n", filename);
        return;
    }

    printf("Contents of %s:\n", filename);
    while (fscanf(fp, "%d", &num) == 1) {
        printf("%d ", num);
    }
    printf("\n");

    fclose(fp);
}

int main() {
    const char *inputFile = "input.txt";
    const char *run1 = "run1.txt";
    const char *run2 = "run2.txt";
    const char *outputFile = "sorted.txt";

    while (!isSingleRun(inputFile)) {
        splitIntoRuns(inputFile, run1, run2);
        mergeRuns(run1, run2, outputFile);

        // Update input for next pass
        FILE *src = fopen(outputFile, "r");
```



```c
        FILE *dst = fopen(inputFile, "w");
        int num;
        while (fscanf(src, "%d", &num) == 1) {
            fprintf(dst, "%d ", num);
        }
        fclose(src);
        fclose(dst);
    }

    printf("Sorting completed!\n");
    displayFile(outputFile);

    return 0;
}
```

Output



```
PS D:\pranjaltiwari029\DFS\hashing> g++ .\natural.c
PS D:\pranjaltiwari029\DFS\hashing> .\a.exe
Sorting completed!
Contents of sorted.txt:
32 54 76 120 135 155
```