WEEK 4

Data Structures

Tarun Thomas Tom
B230589EC

Codes

taruntom1/DS-assignments

Q1

Take a binary tree and do tree traversals

Code

```cpp
#include <iostream>
#include <stack>
#include <vector>
#include <queue>

using namespace std;

struct Node
{
    int data;
    Node* left;
    Node* right;

    Node(int val, Node* l = nullptr, Node* r = nullptr) : data(val), left(l),
right(r) {}
};

class BinaryTree
{
    Node* root;

public:
    BinaryTree(int data)
    {
        root = new Node(data);
    }

    void insert(int val)
    {
        std::queue<Node*> q;
        q.push(root);
        Node* temp;
        while (!q.empty())
        {
            temp = q.front();
            q.pop();

            if (temp->left != nullptr)
```

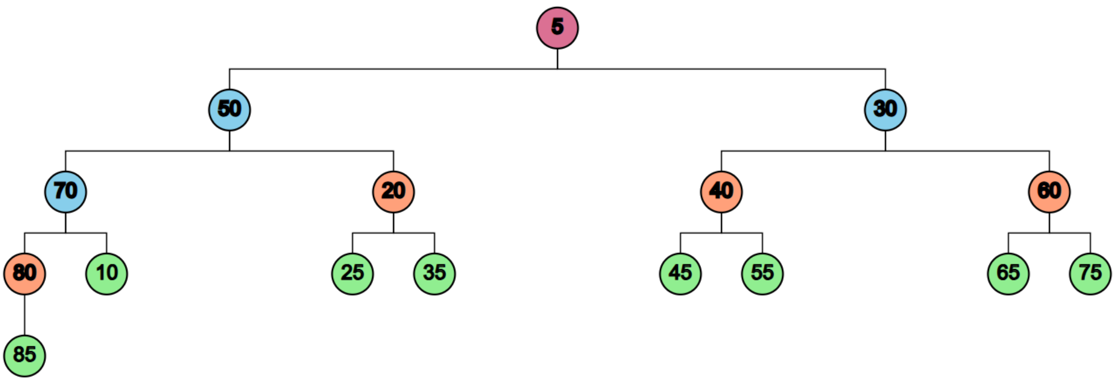
```
                q.push(temp->left);
            else
            {
                temp->left = new Node(val);
                break;
            }

            if (temp->right != nullptr)
                q.push(temp->right);
            else
            {
                temp->right = new Node(val);
                break;
            }
        }
    }

    std::vector<int> BFS_Traversal()
    {
        std::queue<Node*> q;
        std::vector<int> result;
        q.push(root);
        Node* current;

        while (!q.empty())
        {

            current = q.front();
            q.pop();
            result.push_back(current->data);

            if (current->left != nullptr)
                q.push(current->left);

            if (current->right != nullptr)
                q.push(current->right);
        }
        return result;
    }

    std::vector<int> DFS_preorder()
    {
        std::stack<Node*> s;
        std::vector<int> result;
        s.push(root);
        Node* current;

        while (!s.empty())
```

```
    {
        current = s.top();
        s.pop();
        result.push_back(current->data);

        if (current->right != nullptr)
            s.push(current->right);

        if (current->left != nullptr)
            s.push(current->left);
    }
    return result;
}

std::vector<int> DFS_inorder()
{
    std::stack<Node*> s;
    std::vector<int> result;
    Node* current = root;

    while (!s.empty() || current)
    {
        while (current)
        {
            s.push(current);
            current = current->left;
        }

        current = s.top();
        s.pop();
        result.push_back(current->data);
        current = current->right;
    }
    return result;
}

std::vector<int> DFS_postorder()
{
    std::stack<Node*> s1, s2;
    std::vector<int> result;
    Node* current;
    s1.push(root);

    while (!s1.empty())
    {
        current = s1.top();
        s1.pop();
        s2.push(current);
```

```
            if (current->left)
                s1.push(current->left);
            if (current->right)
                s1.push(current->right);
        }
        while (!s2.empty())
        {
            result.push_back(s2.top()->data);
            s2.pop();
        }
        return result;
    }
};

int main()
{
    BinaryTree tree(5);
    tree.insert(50);
    tree.insert(30);
    tree.insert(70);
    tree.insert(20);
    tree.insert(40);
    tree.insert(60);
    tree.insert(80);
    tree.insert(10);
    tree.insert(25);
    tree.insert(35);
    tree.insert(45);
    tree.insert(55);
    tree.insert(65);
    tree.insert(75);
    tree.insert(85);

    std::cout << "BFS Traversal: ";
    std::vector<int> bfs_traversal = tree.BFS_Traversal();

    for (int val : bfs_traversal)
        std::cout << val << " ";

    std::cout << "\nDFS Preorder Traversal: ";
    std::vector<int> dfs_traversal = tree.DFS_preorder();

    for (int val : dfs_traversal)
        std::cout << val << " ";

    std::cout << "\nDFS Inorder Traversal: ";
    dfs_traversal = tree.DFS_inorder();
    for (int val : dfs_traversal)
```

```
        std::cout << val << " ";
    std::cout << "\nDFS Postorder Traversal: ";
    dfs_traversal = tree.DFS_postorder();
    for (int val : dfs_traversal)
        std::cout << val << " ";

    return 0;
}
```

Tree



Output

```
BFS Traversal: 5 50 30 70 20 40 60 80 10 25 35 45 55 65 75 85
DFS Preorder Traversal: 5 50 70 80 85 10 20 25 35 30 40 45 55 60 65 75
DFS Inorder Traversal: 85 80 70 10 50 25 20 35 5 45 40 55 30 65 60 75
DFS Postorder Traversal: 85 80 10 70 25 35 20 50 45 55 40 65 75 60 30 5
```

Q2

2. Construct a BST and do the following on it:

a) Insert
b) Delete
c) Search
d) Max
e) Min
f) Predecessor
g) Successor

Code

```
#include <iostream>
#include <stack>
#include <queue>
#include <vector>
#include <map>
#include <cmath>
#include <iomanip>
#include <string>

struct Node
{
    int data;
    Node *left;
    Node *right;
    Node(int val, Node *l = nullptr, Node *r = nullptr) : data(val), left(l),
right(r) {}
};

class BST
{
private:
    Node *root;

    void treeToMatrixRec(Node *root, int row, int col, int height,
                         std::vector<std::vector<std::string>> &ans)
    {
        if (!root)
        {
            return;
        }

        // Calculate offset for child positions
        int offset = pow(2, height - row - 1);

        // Traverse the left subtree
        if (root->left)
        {
            treeToMatrixRec(root->left, row + 1, col - offset, height, ans);
        }

        // Place the current node's value in the matrix
        ans[row][col] = std::to_string(root->data);

        // Traverse the right subtree
        if (root->right)
        {
            treeToMatrixRec(root->right, row + 1, col + offset, height, ans);
```

```
        }
    }

    // Function to convert the binary tree to a 2D matrix
    std::vector<std::vector<std::string>> treeToMatrix(Node *root)
    {

        // Find the height of the tree
        int height = findHeight(root);

        // Rows are height + 1; columns are 2^(height+1) - 1
        int rows = height + 1;
        int cols = pow(2, height + 1) - 1;

        // Initialize 2D matrix with empty strings
        std::vector<std::vector<std::string>> ans(rows,
std::vector<std::string>(cols, ""));

        // Populate the matrix using inorder traversal
        treeToMatrixRec(root, 0, (cols - 1) / 2, height, ans);

        return ans;
    }

    void print2DArray(std::vector<std::vector<std::string>> &arr)
    {
        for (auto &row : arr)
        {
            for (auto &cell : row)
            {
                if (cell.empty())
                {
                    std::cout << "  ";
                }
                else
                {
                    std::cout << cell;
                }
            }
            std::cout << std::endl;
        }
    }

public:
    BST() : root(nullptr) {}

    void insert(int val)
    {
```

```cpp
    Node *new_node = new Node(val);
    if (root == nullptr)
        root = new_node;
    else
    {
        std::queue<Node *> q;
        q.push(root);
        Node *temp;
        while (!q.empty())
        {
            temp = q.front();
            q.pop();

            if (temp->data > val)
            {
                if (temp->left == nullptr)
                    temp->left = new_node;
                else
                    q.push(temp->left);
            }
            else
            {
                if (temp->right == nullptr)
                    temp->right = new_node;
                else
                    q.push(temp->right);
            }
        }
    }
}

void deleteNode(Node *node)
{

    if (node->right)
    {
        Node *parent;
        Node *min_node = successorLoc(node, &parent);
        node->data = min_node->data;

        delete min_node;
        parent->left = nullptr;
    }

    else if (node->left)
    {
        Node *temp = node->left;
        delete node;
```

```
            node = temp;
        }
        else
        {
            delete node;
        }
    }

    std::vector<int> Traversal()
    {
        std::queue<Node *> q;
        std::vector<int> result;
        q.push(root);
        Node *temp;

        while (!q.empty())
        {

            temp = q.front();
            q.pop();
            result.push_back(temp->data);

            if (temp->left != nullptr)
                q.push(temp->left);

            if (temp->right != nullptr)
                q.push(temp->right);
        }
        return result;
    }

    Node *search(int key, Node *node = nullptr)
    {
        if (node == nullptr)
            node = root;

        while (node != nullptr && key != node->data)
        {
            if (key < node->data)
                node = node->left;
            else
                node = node->right;
        }
        return node;
    }

    Node *minLoc(Node *node, Node **parent = nullptr)
    {
```

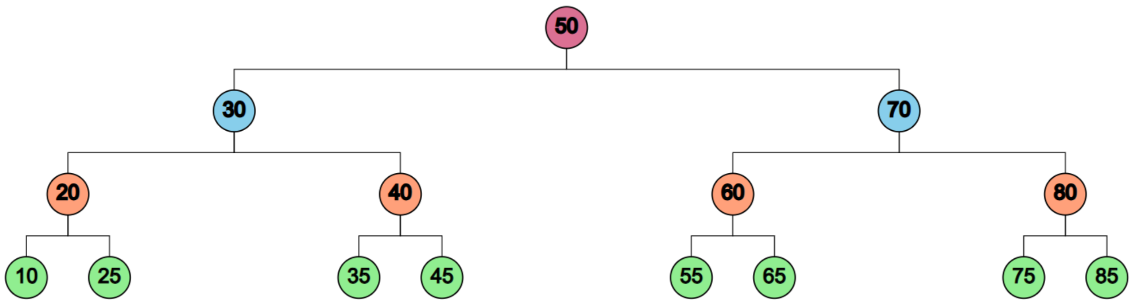
```
    while (node->left->left)
    {
        node = node->left;
    }
    if (parent)
        *parent = node;
    return node->left;
}

Node *maxLoc(Node *node, Node **parent = nullptr)
{
    while (node->right->right)
    {
        node = node->right;
    }
    if (parent)
        *parent = node;
    return node->right;
}

int min(Node *node = nullptr)
{
    if (node == nullptr)
        node = root;

    return minLoc(node)->data;
}

int max(Node *node = nullptr)
{
    if (node == nullptr)
        node = root;

    return maxLoc(node)->data;
}

Node *predecessorLoc(Node *node, Node **parent = nullptr)
{
    Node *curr = node->left;

    return maxLoc(curr, parent);
}
Node *successorLoc(Node *node, Node **parent = nullptr)
{
    Node *curr = node->right;

    return minLoc(curr, parent);
}
```

```
    int predecessor(Node *node)
    {
        if (node == nullptr)
            node = root;
        Node *predecessor = predecessorLoc(node);
        return predecessor->data;
    }
    int successor(Node *node)
    {
        if (node == nullptr)
            node = root;
        Node *successor = successorLoc(node);
        return successor->data;
    }

    int findHeight(Node *root)
    {
        if (!root)
        {
            return -1;
        }

        int leftHeight = findHeight(root->left);
        int rightHeight = findHeight(root->right);

        return std::max(leftHeight, rightHeight) + 1;
    }

    Node *getRoot()
    {
        return root;
    }

    void printTree()
    {
        std::vector<std::vector<std::string>> result = treeToMatrix(root);

        print2DArray(result);
    }
};

int main()
{
    BST tree;

    // insert elements to ensure height of at least 4
    tree.insert(50);
```

```
    tree.insert(30);
    tree.insert(70);
    tree.insert(20);
    tree.insert(40);
    tree.insert(60);
    tree.insert(80);
    tree.insert(10);
    tree.insert(25);
    tree.insert(35);
    tree.insert(45);
    tree.insert(55);
    tree.insert(65);
    tree.insert(75);
    tree.insert(85);

    std::cout << "Inserted elements" << std::endl;

    std::cout << "Tree:" << std::endl;
    tree.printTree();
    std::cout << std::endl;

    // Delete an element
    int deleteKey = 30;
    tree.deleteNode(tree.search(deleteKey));
    std::cout << "Deleted " << deleteKey << std::endl;
    std::cout << "Searching for " << deleteKey << " after deletion: "
              << (tree.search(deleteKey) ? "Found" : "Not Found") <<
std::endl;
    std::cout << "Tree:" << std::endl;
    tree.printTree();
    std::cout << std::endl;

    // Search for an element
    int searchKey = 40;
    std::cout << "Searching for " << searchKey << ": "
              << (tree.search(searchKey) ? "Found" : "Not Found")
              << " Memory location :" << tree.search(searchKey) << std::endl
              << std::endl;

    // Find minimum and maximum
    std::cout << "Minimum value: " << tree.min() << std::endl;
    std::cout << "Maximum value: " << tree.max() << std::endl;

    // Find minimum and maximum under a subtree
    int subtreeKey = 70;
    std::cout << "Minimum value under subtree " << subtreeKey << ": "
              << tree.min(tree.search(subtreeKey)) << std::endl;
    std::cout << "Maximum value under subtree" << subtreeKey << ": "
```

```
              << tree.max(tree.search(subtreeKey)) << std::endl;

    // Find predecessor and successor
    int key = 50;
    std::cout << "Predecessor of " << key << ": "
              << tree.predecessor(tree.search(key)) << std::endl;
    std::cout << "Successor of " << key << ": "
              << tree.successor(tree.search(key)) << std::endl;
    key = 70;
    std::cout << "Predecessor of " << key << ": "
              << tree.predecessor(tree.search(key)) << std::endl;
    std::cout << "Successor of " << key << ": "
              << tree.successor(tree.search(key)) << std::endl;

    return 0;
}
```

Tree



Output

```
Inserted elements
Tree:
              50
      30              70
  20      40      60      80
10  25  35  45  55  65  75  85

Deleted 30
Searching for 30 after deletion: Not Found
Tree:
              50
      35              70
  20      40      60      80
10  25      45  55  65  75  85

Searching for 40: Found Memory location :0000023C5F3C3890

Minimum value: 10
Maximum value: 85

Minimum value under subtree 70: 55
Maximum value under subtree70: 85

Predecessor of 50: 45
Successor of 50: 55
Predecessor of 70: 65
Successor of 70: 75
```

Q3

Implement the following graph algorithms

i) BFS
ii) DFS
iii) PRIM'S ALGORITHM
iv) KRUSKAL'S ALGORITHM
v) DJIKSTRA'S ALGORITHM

Code

```
#include <iostream>
#include <queue>
#include <stack>
#include <vector>
#include <set>
#include <unordered_set>
```

```cpp
#include <unordered_map>
#include <functional>

class Node;

struct edge_to_cost
{
    Node *to;
    int cost;
};

class Node
{
public:
    int data;
    std::vector<edge_to_cost> edges;

    Node(int val)
    {
        data = val;
    }

    void newNeighbour(int data, int cost)
    {
        edges.push_back(edge_to_cost{new Node(data), cost});
    }

    void linkNeighbours(const std::vector<Node *> &newNeighbours, const
std::vector<int> &newCosts)
    {
        if (newNeighbours.size() != newCosts.size())
        {
            std::cerr << "Error: Neighbours and costs must have the same
size!" << std::endl;
            return;
        }
        for (size_t i = 0; i < newNeighbours.size(); ++i)
        {
            edges.push_back(edge_to_cost{newNeighbours[i], newCosts[i]});
            newNeighbours[i]->edges.push_back({this, newCosts[i]});
        }
    }
};

template <typename Func, typename... Args>
void bfs(Node *start, Func func, Args &&...args)
{
    std::unordered_set<Node *> visited;
```

```cpp
    std::queue<Node *> q;

    q.push(start);
    visited.insert(start);

    while (!q.empty())
    {
        auto curr = q.front();
        q.pop();

        func(curr, std::forward<Args>(args)...);

        for (auto edge : curr->edges)
        {
            if (visited.find(edge.to) == visited.end())
            {
                q.push(edge.to);
                visited.insert(edge.to);
            }
        }
    }
}

std::vector<int> dfs(Node *start)
{
    std::set<Node *> visited;
    std::stack<Node *> s;
    std::vector<int> result;

    s.push(start);
    visited.insert(start);

    while (!s.empty())
    {
        auto curr = s.top();
        s.pop();
        result.push_back(curr->data);
        for (auto edge : curr->edges)
        {
            if (visited.find(edge.to) == visited.end())
            {
                s.push(edge.to);
                visited.insert(edge.to);
            }
        }
    }
    return result;
}
```

```cpp
struct Edge
{
    Node *from;
    Node *to;
    int cost;
};

struct compare
{
    bool operator()(const Edge &a, const Edge &b)
    {
        return a.cost > b.cost;
    }
};

std::vector<Edge> prims(Node *start)
{
    std::priority_queue<Edge, std::vector<Edge>, compare> pq;
    std::set<Node *> visited;
    std::vector<Edge> result;

    for (const auto &edge : start->edges)
    {
        pq.push(Edge{start, edge.to, edge.cost});
    }
    visited.insert(start);

    while (!pq.empty())
    {

        auto curr = pq.top();
        pq.pop();
        if (visited.find(curr.to) != visited.end())
            continue;
        visited.insert(curr.to);
        result.push_back(curr);

        for (auto edge : curr.to->edges)
        {

            pq.push(Edge{curr.to, edge.to, edge.cost});
        }
    }

    return result;
}
```

```cpp
void getEdges(Node *node, std::priority_queue<Edge, std::vector<Edge>,
compare> &pq)
{
    if (node == nullptr)
        return;
    for (auto edge : node->edges)
        pq.push(Edge{node, edge.to, edge.cost});
}

void getNodes(Node *node, std::vector<Node *> &nodes)
{
    if (node != nullptr)
    {
        nodes.push_back(node);
    }
}

class DSU
{
    std::unordered_map<Node *, Node *> parent;
    std::unordered_map<Node *, int> rank;

public:
    void makeSet(Node *node)
    {
        parent[node] = node;
        rank[node] = 0;
    }

    Node *find(Node *node)
    {
        if (parent[node] != node)
        {
            parent[node] = find(parent[node]);
        }
        return parent[node];
    }

    void unionSets(Node *x, Node *y)
    {
        Node *rootX = find(x);
        Node *rootY = find(y);

        if (rootX != rootY)
        {
            if (rank[rootX] > rank[rootY])
            {
                parent[rootY] = rootX;
```

```cpp
            }
            else if (rank[rootY] > rank[rootX])
            {
                parent[rootX] = rootY;
            }
            else
            {
                parent[rootY] = rootX;
                rank[rootX]++;
            }
        }
    }
};

std::vector<Edge> kruskalsDSU(Node *start)
{
    std::priority_queue<Edge, std::vector<Edge>, compare> edges;
    DSU dsu;
    std::vector<Node *> nodes;
    bfs(start, getNodes, nodes);

    for (auto node : nodes)
    {
        dsu.makeSet(node);
    }

    bfs(start, getEdges, edges);

    std::vector<Edge> mst_edges;
    while (!edges.empty() && mst_edges.size() < (nodes.size() - 1))
    {
        Edge curr = edges.top();
        edges.pop();

        if (dsu.find(curr.from) != dsu.find(curr.to))
        {
            mst_edges.push_back(curr);
            dsu.unionSets(curr.from, curr.to);
        }
    }
    return mst_edges;
}

std::vector<Edge> kruskals(Node *start)
{
    std::priority_queue<Edge, std::vector<Edge>, compare> edges;
    std::vector<std::unordered_set<Node *>> visited_groups;
    std::vector<Edge> result;
```

```
    bfs(start, getEdges, edges);

    while (!edges.empty())
    {
        Edge curr = edges.top();
        edges.pop();

        int i = 0;
        int edge_from_group = -1;
        int edge_to_group = -1;

        for (auto group : visited_groups)
        {
            if (group.find(curr.from) != group.end())
            {
                edge_from_group = i;
            }
            if (group.find(curr.to) != group.end())
            {
                edge_to_group = i;
            }
            if (edge_from_group != -1 && edge_to_group != -1)
                break;
            i++;
        }

        if (edge_from_group == -1 && edge_to_group == -1)
        {
            visited_groups.push_back(std::unordered_set<Node *>{curr.from,
curr.to});
            result.push_back(curr);
        }
        else if (edge_from_group == -1)
        {
            visited_groups[edge_to_group].insert(curr.from);
            result.push_back(curr);
        }
        else if (edge_to_group == -1)
        {
            visited_groups[edge_from_group].insert(curr.to);
            result.push_back(curr);
        }
        else if (edge_from_group != edge_to_group)
        {
            visited_groups[edge_from_group].insert(visited_groups[edge_to_grou
p].begin(), visited_groups[edge_to_group].end());
```

```
            visited_groups.erase(visited_groups.begin() + edge_to_group);
            result.push_back(curr);
        }
    }

    return result;
}

struct dijkstras_pq_element
{
    Node *curr;
    Node *prev;
    int dist;

    bool operator>(const dijkstras_pq_element &other) const
    {
        return dist > other.dist;
    }
};

std::unordered_map<Node *, std::pair<std::vector<Node *>, int>> dijkstras(Node
*start)
{
    std::unordered_map<Node *, std::pair<int, Node *>> table;
    std::unordered_map<Node *, std::pair<std::vector<Node *>, int>> paths;

    std::priority_queue<dijkstras_pq_element,
std::vector<dijkstras_pq_element>, std::greater<>> pq;
    pq.push({start, nullptr, 0});

    while (!pq.empty())
    {
        dijkstras_pq_element curr = pq.top();
        pq.pop();

        // Skip if node has already been visited
        if (table.find(curr.curr) != table.end())
            continue;

        table[curr.curr] = {curr.dist, curr.prev};

        for (auto edge : curr.curr->edges)
        {
            int new_dist = curr.dist + edge.cost;
            if (table.find(edge.to) == table.end() || new_dist <
table[edge.to].first)
            {
                pq.push({edge.to, curr.curr, new_dist});
```

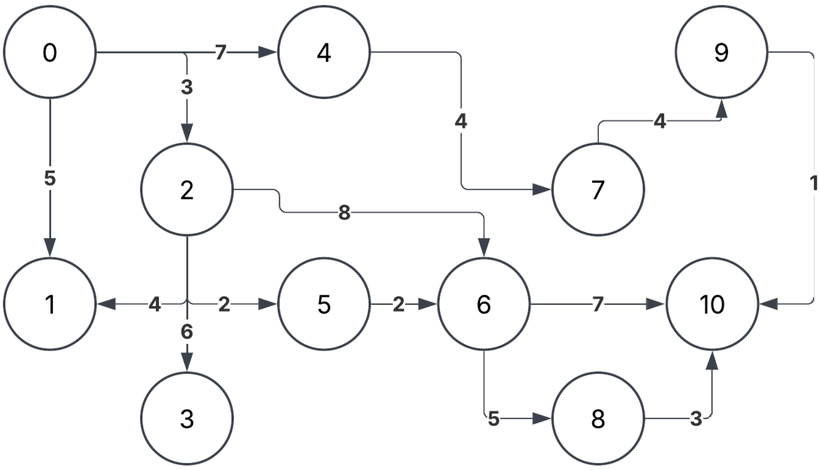
```
            }
        }
    }

    // Reconstruct paths
    for (const auto &[node, info] : table)
    {
        int dist = info.first;
        Node *prev = info.second;

        std::vector<Node *> path;
        Node *current = node;
        while (prev)
        {
            path.push_back(prev);
            prev = table[prev].second;
        }
        std::reverse(path.begin(), path.end());

        paths[node] = {path, dist};
    }

    return paths;
}

int main()
{
    // Create a vector to hold pointers to Node objects
    std::vector<Node *> nodes;

    // Initialize nodes with values from 0 to 10
    for (int i = 0; i < 11; i++)
    {
        nodes.push_back(new Node(i));
    }

    // Establish links between nodes with corresponding edge weights
    nodes[0]->linkNeighbours({nodes[1], nodes[2], nodes[4]}, {5, 3, 7});
    nodes[1]->linkNeighbours({}, {}); // No outgoing edges
    nodes[2]->linkNeighbours({nodes[1], nodes[3], nodes[5], nodes[6]}, {4, 6,
2, 8});
    nodes[3]->linkNeighbours({}, {}); // No outgoing edges
    nodes[4]->linkNeighbours({nodes[7]}, {4});
    nodes[5]->linkNeighbours({nodes[6]}, {2});
    nodes[6]->linkNeighbours({nodes[8], nodes[10]}, {5, 7});
    nodes[7]->linkNeighbours({nodes[9]}, {4});
    nodes[8]->linkNeighbours({nodes[10]}, {3});
    nodes[9]->linkNeighbours({nodes[10]}, {1});
```

```cpp
    nodes[10]->linkNeighbours({}, {}); // No outgoing edges

    // Perform Breadth-First Search (BFS) and store result in bfsresult vector
    std::vector<Node *> bfsresult;
    bfs(nodes[0], getNodes, bfsresult);
    std::cout << "BFS Traversal Order:" << std::endl;

    // Print BFS traversal order
    for (auto i : bfsresult)
    {
        std::cout << i->data << " ";
    }
    std::cout << std::endl
              << std::endl;

    // Perform Depth-First Search (DFS) and store result in dfsresult vector
    std::vector<int> dfsresult = dfs(nodes[0]);
    std::cout << "DFS Traversal Order:" << std::endl;

    // Print DFS traversal order
    for (auto i : dfsresult)
    {
        std::cout << i << " ";
    }
    std::cout << std::endl
              << std::endl;

    // Print the edges of the graph
    std::cout << "Edges" << std::endl;

    std::priority_queue<Edge, std::vector<Edge>, compare> pq;

    bfs(nodes[0], getEdges, pq);

    while (!pq.empty())
    {
        std::cout << pq.top().from->data << "-->" << pq.top().to->data << " "
                  << pq.top().cost << std::endl;
        pq.pop();
    }

    // Perform Prim's algorithm to find the Minimum Spanning Tree (MST)
    std::cout << "Prim's:" << std::endl;
    std::vector<Edge> primsResult = prims(nodes[0]);

    int total_edge_weight = 0;

    for (auto e : primsResult)
```

```
    {
        if (e.from)
        {
            std::cout << e.from->data << "-->" << e.to->data << " "
                      << e.cost << std::endl;
            total_edge_weight += e.cost;
        }
    }

    std::cout << "total edge weight: " << total_edge_weight << std::endl
              << std::endl;

    std::cout << "Kruskal's:" << std::endl;
    std::vector<Edge> kruskalsResult = kruskals(nodes[0]);

    total_edge_weight = 0;

    for (auto e : kruskalsResult)
    {
        if (e.from)
        {
            std::cout << e.from->data << "-->" << e.to->data << " "
                      << e.cost << std::endl;
            total_edge_weight += e.cost;
        }
    }

    std::cout << "total edge weight: " << total_edge_weight << std::endl
              << std::endl;

    std::cout << "Kruskal's DSU:" << std::endl;
    std::vector<Edge> kruskalsResultDSU = kruskalsDSU(nodes[0]);

    total_edge_weight = 0;

    for (auto e : kruskalsResultDSU)
    {
        if (e.from)
        {
            std::cout << e.from->data << "-->" << e.to->data << " " << e.cost
                      << std::endl;
            total_edge_weight += e.cost;
        }
    }

    std::cout << "total edge weight: " << total_edge_weight << std::endl
              << std::endl;
```

```cpp
    std::cout << "Dijkstra's Algorithm:" << std::endl;

    std::unordered_map<Node *, std::pair<std::vector<Node *>, int>>
dijkstra_result = dijkstras(nodes[0]);

    for (auto element : dijkstra_result)
    {
        std::cout << element.first->data << " -> ";
        for (auto node : element.second.first)
        {
            std::cout << node->data << " -> ";
        }
        std::cout << "cost: " << element.second.second << std::endl;
    }
}
```

Graph



Ignore the arrows, the tree is undirected

Output

```
BFS Traversal Order:
0 1 2 4 3 5 6 7 8 10 9

DFS Traversal Order:
0 4 7 9 10 8 6 5 2 3 1
```

```
Prim's:
0-->2 3
2-->5 2
5-->6 2
2-->1 4
6-->8 5
8-->10 3
10-->9 1
9-->7 4
7-->4 4
2-->3 6
total edge weight: 34
```

```
Kruskal's:
10-->9 1
2-->5 2
5-->6 2
2-->0 3
10-->8 3
9-->7 4
2-->1 4
4-->7 4
6-->8 5
3-->2 6
total edge weight: 34
```

```
Dijkstra's Algorithm:
0 -> cost: 0
2 -> 0 -> cost: 3
6 -> 0 -> 2 -> 5 -> cost: 7
1 -> 0 -> cost: 5
3 -> 0 -> 2 -> cost: 9
5 -> 0 -> 2 -> cost: 5
4 -> 0 -> cost: 7
7 -> 0 -> 4 -> cost: 11
8 -> 0 -> 2 -> 5 -> 6 -> cost: 12
10 -> 0 -> 2 -> 5 -> 6 -> cost: 14
9 -> 0 -> 4 -> 7 -> cost: 15
```