Міністерство освіти і науки України
Національний університет «Львівська політехніка»
Кафедра систем штучного інтелекту

Звіт

про виконання лабораторних та практичних робіт блоку № 6

На тему: «Динамічні структури (Черга, Стек, Списки, Дерево). Алгоритми обробки динамічних структур.»

з дисципліни: «Основи програмування»

до:

ВНС Лабораторної Роботи № 10

Алготестер Лабораторної Роботи № 5

Львів 2024

Тема роботи:

Динамічні структури (Черга, Стек, Списки, Дерево). Алгоритми обробки динамічних структур

Мета роботи:

Ознайомитись з основними струкрурами данних , навчитись ітеруватись по ним , ознайомитись з алгоритмами їх обробки.

Джерела:

книга - Stephen Prata - “ *C++ Primer Plus* ”
книга - *Aditya Y.Bhargava - “ Grokking algorithms ”*

Виконання роботи:

Завдання № 3

Requirements :

Vns Lab 10

Time:

Expected: 1 hour

Spent: up to 1 hour

```cpp
#include <iostream>
#include <fstream>
#include <vector>
#include <string>
#include <limits>
#include <sstream>




template <class T>
class LinkedList {
```

```
private:
    struct Node {
        T value;
        Node* next;
        Node* prev;

        Node(T value, Node* next = nullptr, Node* prev = nullptr)
            : value(value), next(next), prev(prev) {}
    };

    Node* head = nullptr;
    Node* tail = nullptr;
    std::size_t size;

public:
    LinkedList() : head(nullptr), tail(nullptr), size(0) {}

    ~LinkedList() {
        clear();
    }

    void push_back(T value) {
        Node* newNode = new Node(value);
        if (!head) {
            head = tail = newNode;
        }
        else {
            tail->next = newNode;
            newNode->prev = tail;
            tail = newNode;
        }
        size++;
    }

    void print() const {
        if (!head) {
            std::cout << "Empty List!" << std::endl;
            return;
        }

        Node* temp = head;
        while (temp) {
            std::cout << temp->value << " ";
            temp = temp->next;
        }
        std::cout << "\b";
```

```
        std::cout << std::endl;
    }

    void save_to_file(const std::string& filename) const {
        std::ofstream file(filename);
        if (!file) {
            throw std::ios_base::failure("Failed to create or open the file: "
+ filename);
        }

        Node* temp = head;
        while (temp) {
            file << temp->value << " ";
            temp = temp->next;
        }
        file.close();
    }

    void load_from_file(const std::string& filename) {
        clear();
        std::ifstream file(filename);
        if (!file) { // Check if the file was opened successfully
            throw std::ios_base::failure("Failed to create or open the file: "
+ filename);
        }
        T value;
        while (file >> value) {
            push_back(value);
        }
        file.close();
    }

    void clear() {
        Node* current = head;
        while (current) {
            Node* temp = current;
            current = current->next;
            delete temp;
        }
        head = tail = nullptr;
        size = 0;
    }

    void insert(int index, T el) {
        if (index < 0 || index > size) {
            throw std::out_of_range("Index out of bounds");
        }
```

```
        Node* newNode = new Node(el);

        if (index == 0) {
            newNode->next = head;
            if (head) {
                head->prev = newNode;
            }
            head = newNode;
            if (size == 0) {
                tail = newNode;
            }
        }
        else if (index == size) {
            newNode->prev = tail;
            tail->next = newNode;
            tail = newNode;
        }
        else {
            Node* current = head;
            for (int i = 0; i < index - 1; ++i) {
                current = current->next;
            }
            newNode->next = current->next;
            newNode->prev = current;
            current->next->prev = newNode;
            current->next = newNode;
        }

        size++;
    }

    void insert(int index, int elCount, T* els) {
        if (elCount <= 0) {
            return;
        }

        Node* newHead = new Node(els[0]);
        Node* current = newHead;

        for (int i = 1; i < elCount; ++i) {
            current->next = new Node(els[i], nullptr, current);
            current = current->next;
        }

        if (index == 0) {
```

```
            if (head) {
                current->next = head;
                head->prev = current;
            }
            head = newHead;
            if (size == 0) {
                tail = current;
            }
        }
        else {
            Node* prev = head;
            for (int i = 0; i < index - 1; ++i) {
                prev = prev->next;
            }
            current->next = prev->next;
            if (prev->next) {
                prev->next->prev = current;
            }
            prev->next = newHead;
            newHead->prev = prev;

            if (index == size) {
                tail = current;
            }
        }

        size += elCount;
    }

    void erase(int index, int count) {
        if (index == 0) {
            Node* temp = head;
            for (int i = 0; i < count; ++i) {
                Node* next = temp->next;
                delete temp;
                temp = next;
            }
            head = temp;
            if (head) {
                head->prev = nullptr;
            }
            else {
                tail = nullptr;
            }
        }
        else {
            Node* prev = head;
```

```
            for (int i = 0; i < index - 1; ++i) {
                prev = prev->next;
            }

            Node* current = prev->next;
            for (int i = 0; i < count; ++i) {
                Node* next = current->next;
                delete current;
                current = next;
            }
            prev->next = current;
            if (current) {
                current->prev = prev;
            }
            else {
                tail = prev;
            }
        }

        size -= count;
    }



    std::size_t get_size()
    {
        return this->size;
    }
};

int main() {
    LinkedList<int> list;

    std::cout << "Test Case 1: Inserting elements 1, 2, 3, 4, 5" << std::endl;
    for (int i = 1; i <= 5; ++i) {
        list.push_back(i);
    }
    list.print();

    std::cout << "Test Case 2: Inserting element 10 at index 2" << std::endl;
    list.insert(2, 10);
    list.print();

    std::cout << "Test Case 3: Erasing 2 elements starting from index 2" <<
std::endl;
    list.erase(2, 2);
    list.print();
```

```
    std::cout << "Test Case 4: Checking size of the list" << std::endl;
    std::cout << "Size: " << list.get_size() << std::endl;

    std::cout << "Test Case 5: Saving list to file 'list.txt'" << std::endl;
    list.save_to_file("D:\\nulp\\OP\\AllEpics\\Sixth\\list.txt"); // Explicit
path ( Vs code g++ specific )

    std::cout << "Test Case 6: Clearing the list" << std::endl;
    list.clear();
    list.print();

    std::cout << "Test Case 7: Loading list from file 'list.txt'" <<
std::endl;
    list.load_from_file("D:\\nulp\\OP\\AllEpics\\Sixth\\list.txt"); //
Explicit path ( Vs code g++ specific )
    list.print();

    std::cout << "Test Case 8: Erasing element at index 1" << std::endl;
    list.erase(1, 1);
    list.print();

    std::cout << "Test Case 9: Inserting element 6 at the end" << std::endl;
    list.push_back(6);
    list.print();

    std::cout << "Test Case 10: Final size of the list" << std::endl;
    std::cout << "Size: " << list.get_size() << std::endl;

    return 0;
}
```

```
Test Case 1: Inserting elements 1, 2, 3, 4, 5
1 2 3 4 5
Test Case 2: Inserting element 10 at index 2
1 2 10 3 4 5
Test Case 3: Erasing 2 elements starting from index 2
1 2 4 5
Test Case 4: Checking size of the list
Size: 4
Test Case 5: Saving list to file 'list.txt'
Test Case 6: Clearing the list
Empty List!
Test Case 7: Loading list from file 'list.txt'
1 2 4 5
Test Case 8: Erasing element at index 1
1 4 5
Test Case 9: Inserting element 6 at the end
1 4 5 6
Test Case 10: Final size of the list
Size: 4
```

Завдання № 4

Requirements :

Algotester Lab 5

Time:

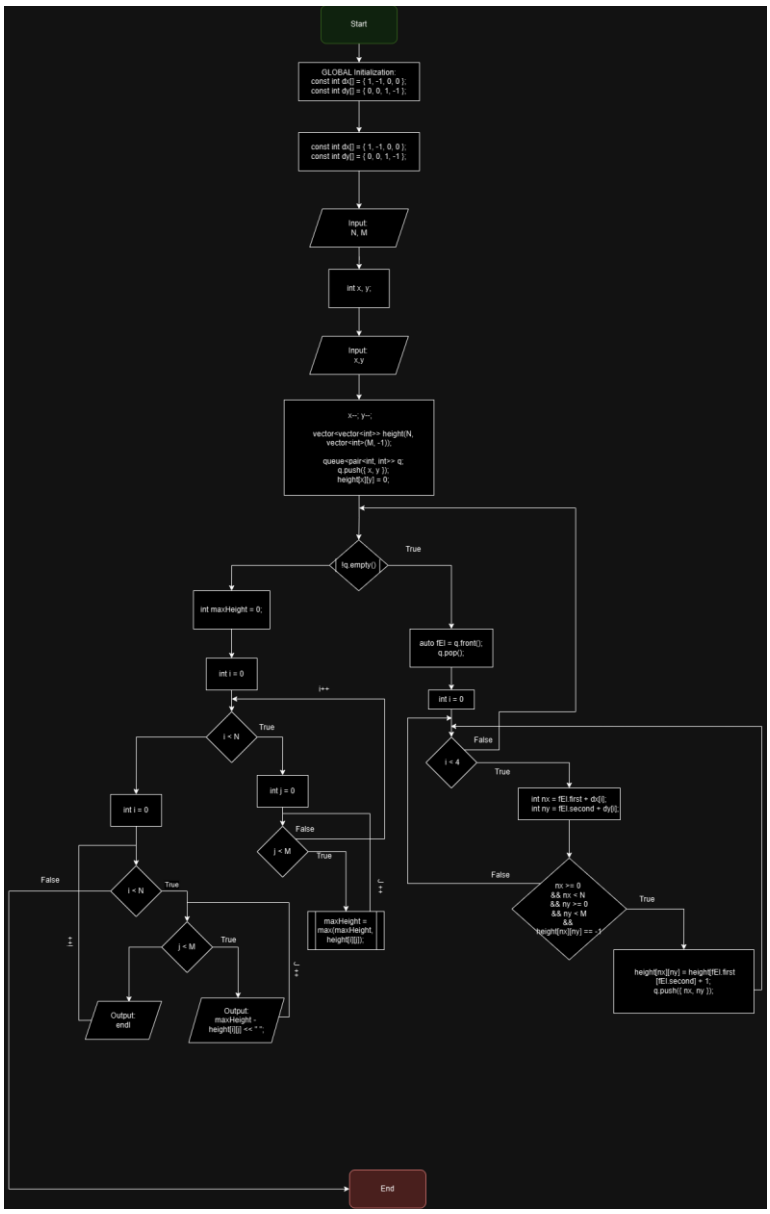
Expected: 1 hour

Spent: up to 3 hours

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

using namespace std;

const int dx[] = { 1, -1, 0, 0 };
const int dy[] = { 0, 0, 1, -1 };

int main() {
    int N, M;
```

```
    cin >> N >> M;
    int x, y;
    cin >> x >> y;
    x--; y--;

    vector<vector<int>> height(N, vector<int>(M, -1));

    queue<pair<int, int>> q;
    q.push({ x, y });
    height[x][y] = 0;

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

        for (int i = 0; i < 4; ++i) {
            int nx = fEl.first + dx[i];
            int ny = fEl.second + dy[i];

            if (nx >= 0 && nx < N && ny >= 0 && ny < M && height[nx][ny] == -
1) {
                height[nx][ny] = height[fEl.first][fEl.second] + 1;
                q.push({ nx, ny });
            }
        }
    }

    int maxHeight = 0;
    for (int i = 0; i < N; ++i) {
        for (int j = 0; j < M; ++j) {
            maxHeight = max(maxHeight, height[i][j]);
        }
    }

    for (int i = 0; i < N; ++i) {
        for (int j = 0; j < M; ++j) {
            cout << maxHeight - height[i][j] << " ";
        }
        cout << endl;
    }

    return 0;
}
```

```
3 4
2 2
1 2 1 0
2 3 2 1
1 2 1 0
```



Завдання № 5

Requirements :

Algotester Lab 78 (v1 , v3)

Time:

Expected: 1 hour

Spent: up to 3 hours

V1:

```cpp
#include <iostream>
#include <vector>
#include <string>
#include <sstream>

enum class operationE {
    insert, erase, size, get, set, print, none
};

operationE parse(const std::string& str) {
    if (str == "erase") return operationE::erase;
    if (str == "insert") return operationE::insert;
    if (str == "size") return operationE::size;
    if (str == "get") return operationE::get;
    if (str == "set") return operationE::set;
    if (str == "print") return operationE::print;
    return operationE::none;
}

template <class T>
class LinkedList {
private:
    struct Node {
        T value;
        Node* next;
        Node* prev;
        Node(T value, Node* next = nullptr, Node* prev = nullptr)
            : value(value), next(next), prev(prev) {}
    };

    Node* head;
    Node* tail;
    std::size_t size;

public:
```

```
    LinkedList() : head(nullptr), tail(nullptr), size(0) {}

    ~LinkedList() {
        clear();
    }

    void push_back(T value) {
        Node* newNode = new Node(value);
        if (!head) {
            head = tail = newNode;
        } else {
            tail->next = newNode;
            newNode->prev = tail;
            tail = newNode;
        }
        ++size;
    }

    void clear() {
        Node* current = head;
        while (current) {
            Node* temp = current;
            current = current->next;
            delete temp;
        }
        head = tail = nullptr;
        size = 0;
    }

    void insert(int index, int elCount, const std::vector<T>& els) {
        if (index < 0 || index > size || elCount <= 0) return;

        Node* newHead = new Node(els[0]);
        Node* current = newHead;

        for (int i = 1; i < elCount; ++i) {
            current->next = new Node(els[i], nullptr, current);
            current = current->next;
        }

        if (index == 0) {
            if (head) {
                current->next = head;
                head->prev = current;
            }
            head = newHead;
```

```
            if (size == 0) {
                tail = current;
            }
        } else {
            Node* prev = head;
            for (int i = 0; i < index - 1; ++i) {
                prev = prev->next;
            }
            current->next = prev->next;
            if (prev->next) {
                prev->next->prev = current;
            }
            prev->next = newHead;
            newHead->prev = prev;

            if (index == size) {
                tail = current;
            }
        }
        size += elCount;
    }

    void erase(int index, int count) {
        if (index < 0 || index >= size || count <= 0) return;

        if (index == 0) {
            Node* temp = head;
            for (int i = 0; i < count && temp; ++i) {
                Node* next = temp->next;
                delete temp;
                temp = next;
                --size;
            }
            head = temp;
            if (head) {
                head->prev = nullptr;
            } else {
                tail = nullptr;
            }
        } else {
            Node* prev = head;
            for (int i = 0; i < index - 1; ++i) {
                prev = prev->next;
            }
            Node* current = prev->next;
            for (int i = 0; i < count && current; ++i) {
                Node* next = current->next;
```

```
                delete current;
                current = next;
                --size;
            }
            prev->next = current;
            if (current) {
                current->prev = prev;
            } else {
                tail = prev;
            }
        }
    }

    std::size_t get_size() const {
        return size;
    }

    T get(std::size_t index) const {
        if (index >= size) throw std::out_of_range("Index out of bounds");
        Node* tmpStep = head;
        for (size_t i = 0; i < index; ++i) {
            tmpStep = tmpStep->next;
        }
        return tmpStep->value;
    }

    void set(std::size_t index, T val) {
        if (index >= size) throw std::out_of_range("Index out of bounds");
        Node* tmpStep = head;
        for (size_t i = 0; i < index; ++i) {
            tmpStep = tmpStep->next;
        }
        tmpStep->value = val;
    }

    friend std::ostream& operator<<(std::ostream& out, const LinkedList<T>&
list) {
        Node* temp = list.head;
        while (temp != nullptr) {
            out << temp->value << ' ';
            temp = temp->next;
        }
        return out;
    }
};

int main() {
```

```cpp
    LinkedList<int> list;
    unsigned int Q;
    std::cin >> Q;
    std::string tmpOpStr;

    for (size_t i = 0; i < Q; ++i) {
        std::cin >> tmpOpStr;

        operationE parseOp = parse(tmpOpStr);
        switch (parseOp) {
            case operationE::insert: {
                int index, n;
                std::cin >> index >> n;
                std::vector<int> N(n);
                for (int& num : N) {
                    std::cin >> num;
                }
                list.insert(index, n, N);
                break;
            }
            case operationE::size:
                std::cout << list.get_size() << std::endl;
                break;
            case operationE::get: {
                int index;
                std::cin >> index;
                std::cout << list.get(index) << std::endl;
                break;
            }
            case operationE::set: {
                int index, value;
                std::cin >> index >> value;
                list.set(index, value);
                break;
            }
            case operationE::print:
                std::cout << list << std::endl;
                break;
            case operationE::erase: {
                int index, count;
                std::cin >> index >> count;
                list.erase(index, count);
                break;
            }
            default:
                break;
        }
```

```
    }
    return 0;
}
```

```
5

insert
0 3
1 2 3

erase
0 2

set
0 10

size
1

print
10
```

V3:

```
#include <iostream>
#include <string>
#include <algorithm>

using namespace std;

enum Operation {
    INSERT,
    SIZE,
    PRINT,
    CONTAINS,
    UNKNOWN
};

Operation getOperation(const string& command) {
    if (command == "insert") return INSERT;
    if (command == "size") return SIZE;
    if (command == "print") return PRINT;
    if (command == "contains") return CONTAINS;
    return UNKNOWN;
}
```

```cpp
template<typename T>
class Tree {
private:
    struct Node {
        T value;
        Node* left;
        Node* right;
        Node(T val) : value(val), left(nullptr), right(nullptr) {}
    };

    Node* root;
    int size;

    void clear(Node* root) {
        if (root != nullptr) {
            clear(root->left);
            clear(root->right);
            delete root;
        }
    }

    void insertP(Node* node, T value) {
        if (value < node->value) {
            if (node->left == nullptr) {
                node->left = new Node(value);
                size++;
            }
            else {
                insertP(node->left, value);
            }
        }
        else if (value > node->value) {
            if (node->right == nullptr) {
                node->right = new Node(value);
                size++;
            }
            else {
                insertP(node->right, value);
            }
        }
    }

    bool containsP(Node* node, T value) {
        if (node == nullptr) return false;
        if (value == node->value) return true;
        if (value < node->value) return containsP(node->left, value);
```

```
        return containsP(node->right, value);
    }

    void printP(Node* node, ostream& os) const {
        if (node != nullptr) {
            printP(node->left, os);
            os << node->value << " ";
            printP(node->right, os);
        }
    }

public:
    Tree() : root(nullptr), size(0) {}

    ~Tree() {
        clear(root);
    }

    void insert(T value) {
        if (root == nullptr) {
            root = new Node(value);
            size++;
        }
        else {
            insertP(root, value);
        }
    }

    bool contains(T value) {
        return containsP(root, value);
    }

    int getSize() const {
        return size;
    }

    friend ostream& operator<<(ostream& os, const Tree& tree) {
        tree.printP(tree.root, os);
        return os;
    }
};

int main() {
    int Q;
    cin >> Q;
    Tree<int> tree;
```

```
    for (int i = 0; i < Q; i++) {
        string option;
        cin >> option;
        Operation operation = getOperation(option);

        switch (operation) {
        case INSERT: {
            int value;
            cin >> value;
            tree.insert(value);
            break;
        }
        case SIZE: {
            cout << tree.getSize() << endl;
            break;
        }
        case CONTAINS: {
            int value;
            cin >> value;
            cout << (tree.contains(value) ? "Yes" : "No") << endl;
            break;
        }
        case PRINT: {
            cout << tree;
            break;
        }
        default:
            break;
        }
    }
}
```

```
11

size
0
insert 5
insert 4
print
4 5 insert 5
print
4 5 insert 1
print
1 4 5 contains 5
Yes
contains 0
No
size
3
```

Завдання № 6

Requirements :

Class Practice Task

Time:

Expected: 1 hour

Spent: up to 1 hour

```cpp
#include <iostream>

// Node structure for linked list
struct Node {
    int data;
    Node* next;
    Node(int val) : data(val), next(nullptr) {}
};

// Function to reverse the linked list
```

```cpp
Node* reverse(Node* head) {
    Node* prev = nullptr;
    Node* current = head;
    Node* next = nullptr;

    while (current != nullptr) {
        next = current->next;  // Store next node
        current->next = prev;  // Reverse the link
        prev = current;        // Move prev and current one step forward
        current = next;
    }
    return prev;  // New head of the reversed list
}

// Function to print the linked list
void printList(Node* head) {
    while (head != nullptr) {
        std::cout << head->data << " ";
        head = head->next;
    }
    std::cout << std::endl;
}

// Function to compare two linked lists
bool compare(Node* h1, Node* h2) {
    while (h1 != nullptr && h2 != nullptr) {
        if (h1->data != h2->data) {
            return false; // Data mismatch
        }
        h1 = h1->next;
        h2 = h2->next;
    }
    return h1 == nullptr && h2 == nullptr; // Both must reach the end
}

// Function to add two large numbers represented as linked lists
Node* add(Node* n1, Node* n2) {
    Node dummy(0);  // Dummy node to simplify the process
    Node* current = &dummy;
    int carry = 0;

    while (n1 != nullptr || n2 != nullptr || carry) {
        int sum = carry;
        if (n1 != nullptr) {
            sum += n1->data;
            n1 = n1->next;
        }
```

```
        if (n2 != nullptr) {
            sum += n2->data;
            n2 = n2->next;
        }
        carry = sum / 10; // Update carry
        current->next = new Node(sum % 10); // Create new node
        current = current->next;
    }
    return dummy.next; // Return the next node to dummy
}

// TreeNode structure for binary tree
struct TreeNode {
    int value;
    TreeNode* left;
    TreeNode* right;

    TreeNode(int val) : value(val), left(nullptr), right(nullptr) {}
};

// Function to create a mirrored (flipped) copy of the tree
TreeNode* create_mirror_flip(TreeNode* root) {
    if (root == nullptr) return nullptr;

    TreeNode* new_root = new TreeNode(root->value);
    new_root->left = create_mirror_flip(root->right);
    new_root->right = create_mirror_flip(root->left);

    return new_root;
}

// Function to print tree nodes in in-order traversal
void printTree(TreeNode* root) {
    if (root != nullptr) {
        printTree(root->left);
        std::cout << root->value << " ";
        printTree(root->right);
    }
}

// Function to update tree nodes' values as the sum of their subtrees
void tree_sum(TreeNode* root) {
    if (root == nullptr) return;

    int left_sum = 0;
    int right_sum = 0;
```

```
    if (root->left != nullptr) {
        left_sum += root->left->value;
    }
    if (root->right != nullptr) {
        right_sum += root->right->value;
    }

    tree_sum(root->left);
    tree_sum(root->right);

    if(!root->left && !root->right) return;
    root->value = left_sum + right_sum;
}

int main() {
    // Linked List Operations
    Node* head = new Node(1);
    head->next = new Node(2);
    head->next->next = new Node(3);
    head->next->next->next = new Node(4);

    std::cout << "Original Linked List: ";
    printList(head);

    head = reverse(head);
    std::cout << "Reversed Linked List: ";
    printList(head);

    Node* list1 = new Node(1);
    list1->next = new Node(2);
    list1->next->next = new Node(3);

    Node* list2 = new Node(1);
    list2->next = new Node(2);
    list2->next->next = new Node(3);

    std::cout << "Are lists equal? " << (compare(list1, list2) ? "Yes" : "No")
<< std::endl;

    list2->next->next->data = 4;
    std::cout << "Are lists equal after modification? " << (compare(list1,
list2) ? "Yes" : "No") << std::endl;

    Node* num1 = new Node(9);
```

```
    num1->next = new Node(9);
    num1->next->next = new Node(9);

    Node* num2 = new Node(1);
    num2->next = new Node(0);
    num2->next->next = new Node(0);

    Node* sum = add(num1, num2);
    std::cout << "Sum of numbers: ";
    printList(sum);

    // Binary Tree Operations

    //structure:
    //       1
    //     /   \
    //    2     3
    //   / \
    //  4   5
    TreeNode* root = new TreeNode(1);
    root->left = new TreeNode(2);
    root->right = new TreeNode(3);
    root->left->left = new TreeNode(4);
    root->left->right = new TreeNode(5);

    std::cout << "Original Tree: ";
    printTree(root);
    std::cout << std::endl;

    TreeNode* mirroredRoot = create_mirror_flip(root);
    std::cout << "Mirrored Tree: ";
    printTree(mirroredRoot);
    std::cout << std::endl;



    // structure:
    //       1
    //     /   \
    //    2     3
    //   / \
    //  4   5
    TreeNode* sumTreeRoot = new TreeNode(1);
    sumTreeRoot->left = new TreeNode(2);
    sumTreeRoot->right = new TreeNode(3);
    sumTreeRoot->left->left = new TreeNode(4);
    sumTreeRoot->left->right = new TreeNode(5);
```

```
    std::cout << "Tree before summing: ";
    printTree(sumTreeRoot);
    std::cout << std::endl;

    tree_sum(sumTreeRoot);
    std::cout << "Tree after summing subtrees: ";
    printTree(sumTreeRoot);
    std::cout << std::endl;

    return 0;
}
```

```
Original Linked List: 1 2 3 4
Reversed Linked List: 4 3 2 1
Are lists equal? Yes
Are lists equal after modification? No
Sum of numbers: 0 0 0 1
Original Tree: 4 2 5 1 3
Mirrored Tree: 3 1 5 2 4
Tree before summing: 4 2 5 1 3
Tree after summing subtrees: 4 9 5 5 3
```

Завдання № 7

Requirements :

Self Practise Task

Time:

Expected: 1 hour

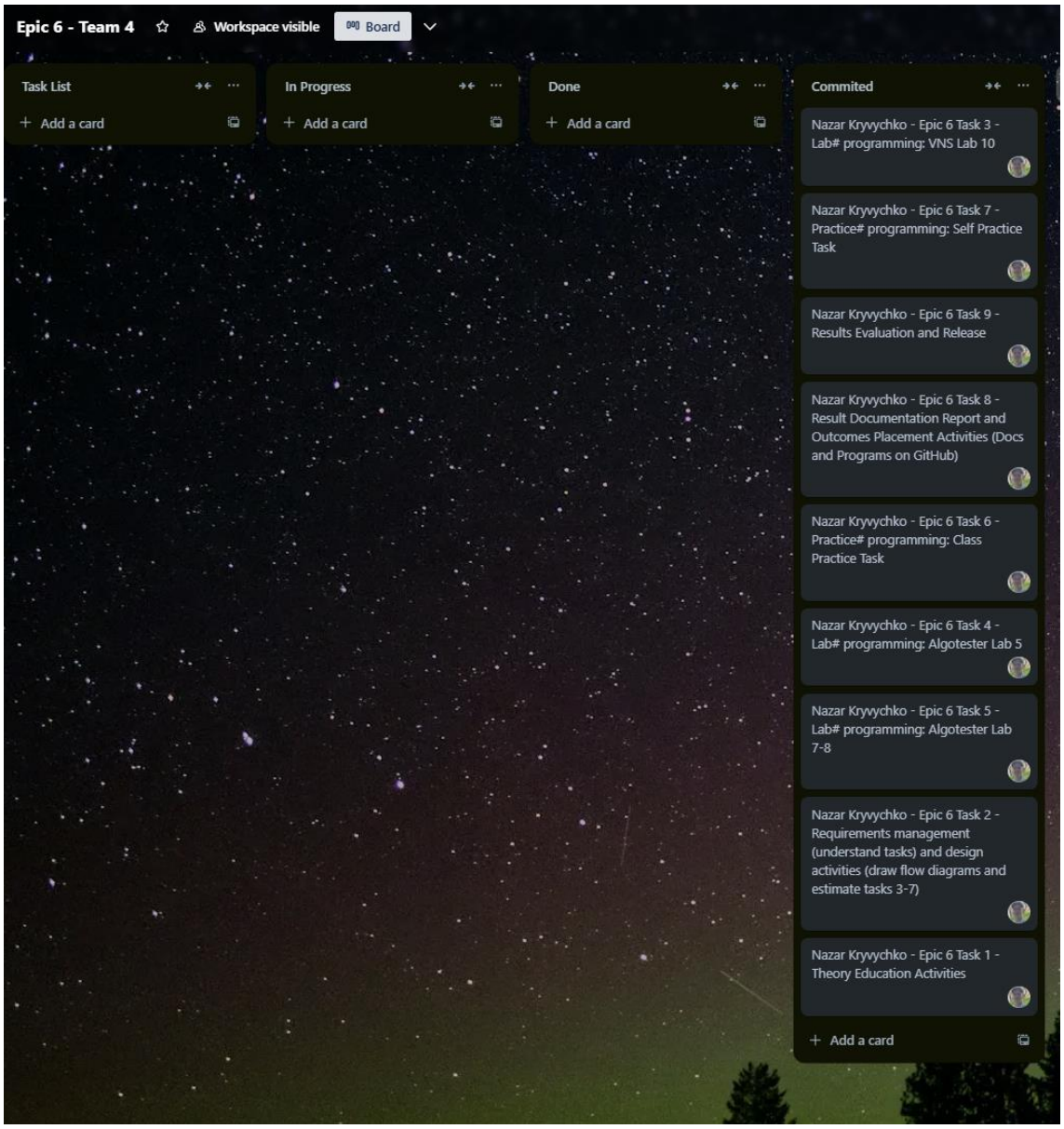
Spent: up to 30 mins

```
#include <iostream>
#include <algorithm>

int main() {
    int n, k;
    std::cin >> n >> k;
```

```
    int* teeths = new int[n];
    for (int i = 0; i < n; i++) {
        std::cin >> teeths[i];
    }

    int maxConsecutive = 0;
    int currentConsecutive = 0;

    for (int i = 0; i < n; i++) {
        if (teeths[i] >= k) {
            currentConsecutive++;
            maxConsecutive = std::max(maxConsecutive, currentConsecutive);
        } else {
            currentConsecutive = 0;
        }
    }

    std::cout << maxConsecutive;

    delete[] teeths;
    return 0;
}
```

```
5
3
4 5 6 2 2
3
```

Trello Configuration & Team meetings:



Meeting :

Pull Request: Link

Висновок:
Я закріпив знання стурктур данних та навчився декілька варіантів ітерації по них.