Câu hỏi 1

Chính xác

Chấm điểm của 1,00

Given class SplayTree definition:

```
class SplayTree {
    struct Node {
        int val;
        Node* pLeft;
        Node* pRight;
        Node* pParent;
        Node(int val = 0, Node* l = nullptr, Node* r = nullptr, Node* par = nullptr) : val(val), pLeft(l), pRight(r),
pParent(par) { }
    };
    Node* root;

    // print the tree structure for local testing
    void printBinaryTree(string prefix, const Node* root, bool isLeft, bool hasRightSibling) {
        if (!root && isLeft && hasRightSibling) {
            cout << prefix << "├──\n";
        }
        if (!root) return;
        cout << prefix;
        if (isLeft && hasRightSibling)
            cout << "├──";
        else
            cout << "└──";
        cout << root->val << '\n';
        printBinaryTree(prefix + (isLeft && hasRightSibling ? "|  " : "   "), root->pLeft, true, root->pRight);
        printBinaryTree(prefix + (isLeft && hasRightSibling ? "|  " : "   "), root->pRight, false, root->pRight);
    }

    void printPreorder(Node* p) {
        if (!p) {
            return;
        }
        cout << p->val << ' ';
        printPreorder(p->pLeft);
        printPreorder(p->pRight);
    }
public:
    SplayTree() {
        root = nullptr;
    }
    ~SplayTree() {
        // Ignore deleting all nodes in the tree
    }

    void printBinaryTree() {
        printBinaryTree("", root, false, false);
    }

    void printPreorder() {
        printPreorder(root);
        cout << "\n";
    }

    void splay(Node* p) {
        // To Do
    }

    void insert(int val) {
        // To Do
    }
};
```

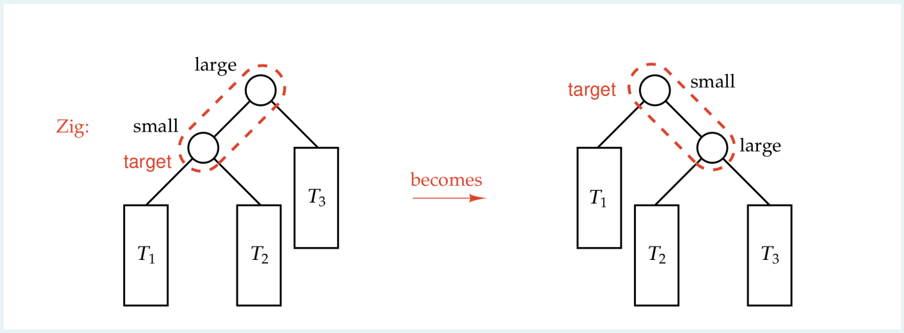
Implement the following method:

1. void splay(Node* p): bottom-up splaying a Node

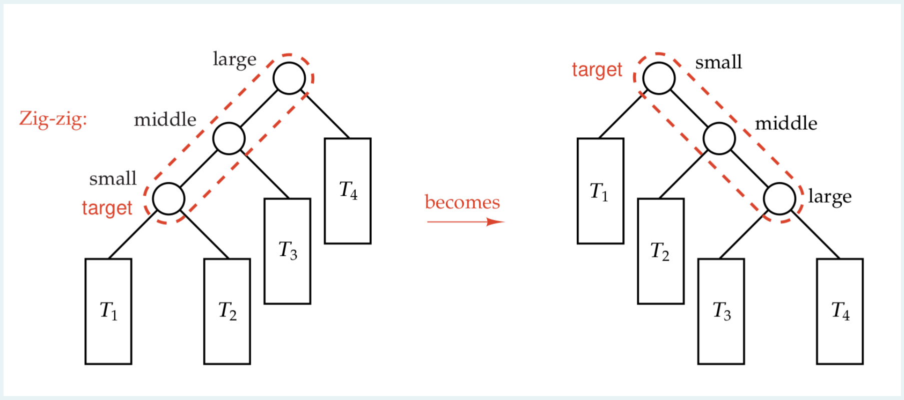
When a splay operation is performed on Node p, it will be moved to the root. To perform a splay operation we carry out a sequence of splay steps, each of which moves p closer to the root.

The three types of splay steps are:

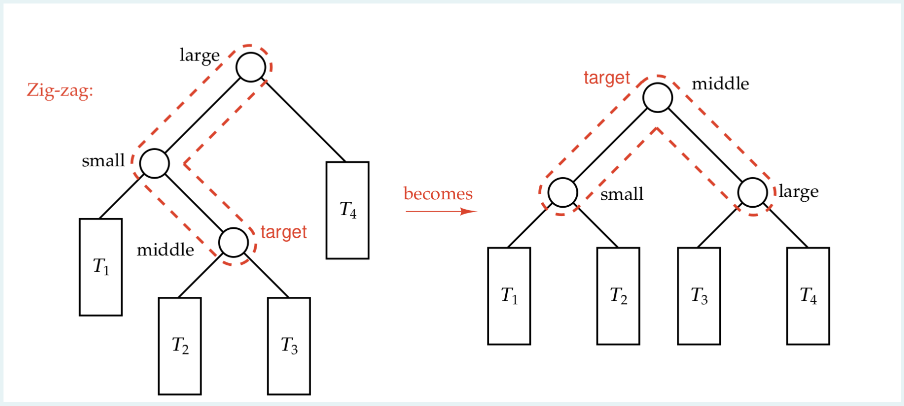
- Zig step



- Zig-zig step:



- Zig-zag step:



Note: there are also zag, zag-zag and zag-zig step but we don't show them here

2. void insert(int val):

To insert a value val into a splay tree:

+ Insert val as with a normal binary search tree.

+ When the new value is inserted, a splay operation is performed. As a result, the newly inserted node becomes the root of the tree.

Note: In a splay tree, the values the in left subtree <= root's value <= the values in the right subtree. In this exercise, when inserting a duplicate value, you have to insert it to the right subtree to pass the testcases.

Constraint of testcases:

+ number of operation <= 10^4

+ 1 <= val <= 10^5

For example:

Test	Input	Result

`SplayTree tree;`
`int query;`
`cin >> query;`
`for(int i = 0; i < query; i++) {`
`    string op;`
`    int val;`
`    cin >> op >> val;`
`    if (op == "insert")`
`        tree.insert(val);`
`}`
`// print preorder traversal of the tree`
`tree.printPreorder();`
`// print structure of the tree`
`tree.printBinaryTree();`
	6
	insert 50
	insert 70
	insert 30
	insert 80
	insert 100
	insert 90
		`90 80 30 70 50 100`
		`└──90`
		`   ├──80`
		`   |  └──30`
		`   |     ├──`
		`   |     └──70`
		`   |        └──50`
		`   └──100`

`SplayTree tree;`
`int query;`
`cin >> query;`
`for(int i = 0; i < query; i++) {`
`    string op;`
`    int val;`
`    cin >> op >> val;`
`    if (op == "insert")`
`        tree.insert(val);`
`}`
`// print preorder traversal of the tree`
`tree.printPreorder();`
`// print structure of the tree`
`tree.printBinaryTree();`
	6
	insert 95
	insert 200
	insert 80
	insert 100
	insert 200
	insert 95
		`95 95 80 200 100 200`
		`└──95`
		`   ├──95`
		`   |  └──80`
		`   └──200`
		`      └──100`
		`         ├──`
		`         └──200`

Answer: (penalty regime: 0 %)

Reset answer

```cpp
// Hàm rotateRight dùng để quay cây con gốc tại node p sang phải
void rotateRight(Node* p) {
    Node* q = p->pLeft; // Node q là con trái của p
    if (p->pParent) {
        // Nếu p có cha, cập nhật con của cha p thành q
        if (p->pParent->pLeft == p) {
            p->pParent->pLeft = q;
        } else {
            p->pParent->pRight = q;
        }
    }
    if (q) {
        q->pParent = p->pParent; // Cập nhật cha của q thành cha của p
    }
    p->pLeft = q->pRight; // Cập nhật con trái của p thành con phải của q
    if (p->pLeft) {
        p->pLeft->pParent = p; // Cập nhật cha của con trái p thành p
    }
    p->pParent = q; // Cập nhật cha của p thành q
    if (q) {
        q->pRight = p; // Cập nhật con phải của q thành p
    }
}

// Hàm rotateLeft tương tự như hàm rotateRight nhưng quay cây con sang trái
void rotateLeft(Node* p) {
    Node* q = p->pRight;
    if (p->pParent) {
        if (p->pParent->pLeft == p) {
            p->pParent->pLeft = q;
        } else {
            p->pParent->pRight = q;
        }
    }
    if (q) {
        q->pParent = p->pParent;
    }
    p->pRight = q->pLeft;
```

Precheck Kiểm tra

	Test	Input	Expected	Got	

✓	`SplayTree tree;`
	`int query;`
	`cin >> query;`
	`for(int i = 0; i < query; i++) {`
	`    string op;`
	`    int val;`
	`    cin >> op >> val;`
	`    if (op == "insert")`
	`        tree.insert(val);`
	`}`
	`// print preorder traversal of the tree`
	`tree.printPreorder();`
	`// print structure of the tree`
	`tree.printBinaryTree();`
		6
		insert 50
		insert 70
		insert 30
		insert 80
		insert 100
		insert 90
			`90 80 30 70 50 100`
			`└─90`
			`  ├─80`
			`  │  └─30`
			`  │     ├─`
			`  │     └─70`
			`  │        └─50`
			`  └─100`
				`90 80 30 70 50 100`
				`└─90`
				`  ├─80`
				`  │  └─30`
				`  │     ├─`
				`  │     └─70`
				`  │        └─50`
				`  └─100`
					✓

✓	`SplayTree tree;`
	`int query;`
	`cin >> query;`
	`for(int i = 0; i < query; i++) {`
	`    string op;`
	`    int val;`
	`    cin >> op >> val;`
	`    if (op == "insert")`
	`        tree.insert(val);`
	`}`
	`// print preorder traversal of the tree`
	`tree.printPreorder();`
	`// print structure of the tree`
	`tree.printBinaryTree();`
		6
		insert 95
		insert 200
		insert 80
		insert 100
		insert 200
		insert 95
			`95 95 80 200 100 200`
			`└─95`
			`  ├─95`
			`  │  └─80`
			`  └─200`
			`     └─100`
			`        ├─`
			`        └─200`
				`95 95 80 200 100 200`
				`└─95`
				`  ├─95`
				`  │  └─80`
				`  └─200`
				`     └─100`
				`        ├─`
				`        └─200`
					✓

Passed all tests! ✓

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Câu hỏi 2

Chính xác

Chấm điểm của 1,00

Given class SplayTree definition:

```
class SplayTree {
    struct Node {
        int val;
        Node* pLeft;
        Node* pRight;
        Node* pParent;
        Node(int val = 0, Node* l = nullptr, Node* r = nullptr, Node* par = nullptr) : val(val), pLeft(l), pRight(r),
pParent(par) { }
    };
```

```
    Node* root;
```

```

    // print the tree structure for local testing
    void printBinaryTree(string prefix, const Node* root, bool isLeft, bool hasRightSibling) {
        if (!root && isLeft && hasRightSibling) {
            cout << prefix << "├──\n";
        }
        if (!root) return;
        cout << prefix;
        if (isLeft && hasRightSibling)
            cout << "├──";
        else
            cout << "└──";
        cout << root->val << '\n';
        printBinaryTree(prefix + (isLeft && hasRightSibling ? "|  " : "   "), root->pLeft, true, root->pRight);
        printBinaryTree(prefix + (isLeft && hasRightSibling ? "|  " : "   "), root->pRight, false, root->pRight);
    }
```

```

    void printPreorder(Node* p) {
        if (!p) {
            return;
        }
        cout << p->val << ' ';
        printPreorder(p->pLeft);
        printPreorder(p->pRight);
    }
```

```
public:
    SplayTree() {
        root = nullptr;
    }
```

```

    ~SplayTree() {
        // Ignore deleting all nodes in the tree
    }
```

```

    void printBinaryTree() {
        printBinaryTree("", root, false, false);
    }
    void printPreorder() {
        printPreorder(root);
        cout << "\n";
    }
```

```
    void splay(Node* p);
```

```
    void insert(int val);
```

```
    bool search(int val) {
        // To Do
    }
};
```

Method splay and insert are already implemented

You have to implement the following method:

bool search(int val): search for the value val in the tree.

The search operation in splay tree do the same thing as BST search. In addition, it also splays the node containing the value to the root.

+ If the search is successful, the node that is found will become the new root and the function return true.

+ Else, the last accessed node will be splayed and become the new root and the function return false.

Constraints of the testcases:

+ number of operation <= 10^4

+ 1 <= val <= 10^5

For example:

Test	Input	Result

```
SplayTree tree;
int query;
cin >> query;
for(int i = 0; i < query; i++) {
    string op;
    int val;
    cin >> op >> val;
    if (op == "insert")
        tree.insert(val);
    else if (op == "search")
        cout << (tree.search(val) ? "found" : "not found") << '\n';
    else if (op == "print")
        tree.printPreorder();
}
tree.printBinaryTree();
```
	```
	8
	insert 95
	insert 200
	insert 80
	search 100
	insert 55
	insert 100
	search 95
	print 0
	```
		```
		not found
		found
		95 55 80 100 200
		└─95
		   ├─55
		   │  ├─
		   │  └─80
		   └─100
		      ├─
		      └─200
		```

Test

```
SplayTree tree;
int query;
cin >> query;
for(int i = 0; i < query; i++) {
    string op;
    int val;
    cin >> op >> val;
    if (op == "insert")
        tree.insert(val);
    else if (op == "search")
        cout << (tree.search(val) ? "found" : "not found") << '\n';
    else if (op == "print")
        tree.printPreorder();
}
tree.printBinaryTree();
```

Input

```
5
insert 100
insert 200
insert 300
insert 200
search 250
```

Result

```
not found
└─300
  └─200
    └─200
      └─100
```

Answer: (penalty regime: 0 %)

Reset answer

```
bool search(int val) {
    Node* p = root;  // Khởi tạo con trỏ p tại gốc
    Node* q = nullptr;  // Khởi tạo con trỏ q, dùng để lưu nút cuối cùng được truy cập

    // Duyệt cây tìm kiếm nhị phân
    while (p) {
        q = p;
        if (val < p->val) {
            p = p->pLeft;  // Di chuyển sang nút con bên trái nếu giá trị cần tìm nhỏ hơn giá trị tại nút
        } else if (val > p->val) {
            p = p->pRight;  // Di chuyển sang nút con bên phải nếu giá trị cần tìm lớn hơn giá trị tại nút
        } else {
            splay(p);  // Nếu tìm thấy giá trị, đưa nút chứa giá trị đó lên làm gốc và trả về true
            return true;
        }
    }

    // Nếu p là null, tức là giá trị không có trong cây
    // Nút cuối cùng được truy cập sẽ được đưa lên làm gốc
    if (q) {
        splay(q);
    }
    return false;  // Trả về false nếu không tìm thấy giá trị
}

```

Precheck Kiểm tra

	Test	Input	Expected	Got	

✓	SplayTree tree;
	int query;
	cin >> query;
	for(int i = 0; i < query; i++) {
	    string op;
	    int val;
	    cin >> op >> val;
	    if (op == "insert")
	        tree.insert(val);
	    else if (op == "search")
	        cout << (tree.search(val) ? "found" : "not found") <<
	'\n';
	    else if (op == "print")
	        tree.printPreorder();
	}
	tree.printBinaryTree();
		8
		insert 95
		insert
		200
		insert 80
		search
		100
		insert 55
		insert
		100
		search 95
		print 0
			not found
			found
			95 55 80 100
			200
			└──95
			    ├──55
			    │ ├──
			    │ └──80
			    └──100
			        ├──
			        └──200
				not found
				found
				95 55 80 100
				200
				└──95
				    ├──55
				    │ ├──
				    │ └──80
				    └──100
				        ├──
				        └──200
					✓

✓	SplayTree tree;
	int query;
	cin >> query;
	for(int i = 0; i < query; i++) {
	    string op;
	    int val;
	    cin >> op >> val;
	    if (op == "insert")
	        tree.insert(val);
	    else if (op == "search")
	        cout << (tree.search(val) ? "found" : "not found") <<
	'\n';
	    else if (op == "print")
	        tree.printPreorder();
	}
	tree.printBinaryTree();
		5
		insert
		100
		insert
		200
		insert
		300
		insert
		200
		search
		250
			not found
			└──300
			    └──200
			        └──200
			            └──100
				not found
				└──300
				    └──200
				        └──200
				            └──100
					✓

Passed all tests! ✓

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Câu hỏi 3

Chính xác

Chấm điểm của 1,00

Given class SplayTree definition:

```
class SplayTree {
    struct Node {
        int val;
        Node* pLeft;
        Node* pRight;
        Node* pParent;
        Node(int val = 0, Node* l = nullptr, Node* r = nullptr, Node* par = nullptr) : val(val), pLeft(l), pRight(r),
pParent(par) { }
    };
    Node* root;

    // print the tree structure for local testing
    void printBinaryTree(string prefix, const Node* root, bool isLeft, bool hasRightSibling) {
        if (!root && isLeft && hasRightSibling) {
            cout << prefix << "├──\n";
        }
        if (!root) return;
        cout << prefix;
        if (isLeft && hasRightSibling)
            cout << "├──";
        else
            cout << "└──";
        cout << root->val << '\n';
        printBinaryTree(prefix + (isLeft && hasRightSibling ? "|  " : "   "), root->pLeft, true, root->pRight);
        printBinaryTree(prefix + (isLeft && hasRightSibling ? "|  " : "   "), root->pRight, false, root->pRight);
    }
```

```

    void printPreorder(Node* p) {
        if (!p) {
            return;
        }
        cout << p->val << ' ';
        printPreorder(p->pLeft);
        printPreorder(p->pRight);
    }
public:
    SplayTree() {
        root = nullptr;
    }
```

```
    ~SplayTree() {
        // Ignore deleting all nodes in the tree
    }
```

```
    void printBinaryTree() {
        printBinaryTree("", root, false, false);
    }
```

```
    void printPreorder() {
        printPreorder(root);
        cout << "\n";
    }
```

```
    void splay(Node* p);
```

```
    void insert(int val);
    bool search(int val);
```

```
    Node* remove(int val) {
        // To Do
    }
};
```

The methods splay, insert and search are already implemented.

Implement the following method:

Node* remove(int val): remove the first Node with value equal to val from the tree and return it.

To perform remove operation on splay tree:

1. If root is NULL, return the root

2. Search for the first node containing the given value val and splay it. If val is present, the found node will become the root. Else the last accessed leaf node becomes the root.

3. If new root's value is not equal to val, return NULL as val is not present.

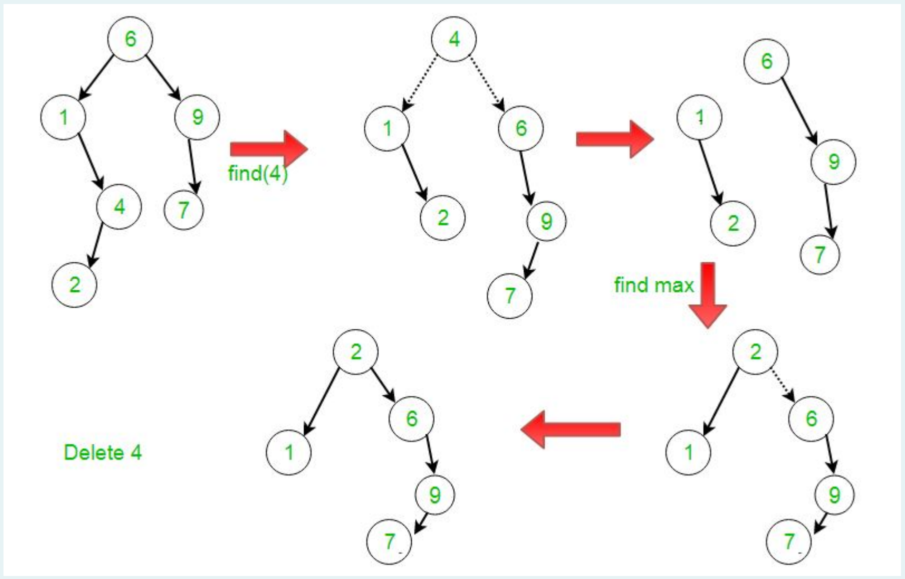
4. Else the value val is present, we remove root from the tree by the following steps:

  4.1 Split the tree into two tree: tree1 = root's left subtree and tree2 = root's right subtree

  4.2 If tree1 is NULL, tree2 is the new root

  4.3 Else, splay the leaf node with the largest value in tree1. tree1 will be a left skewed binary tree. Make tree2 the right subtree of tree1. tree1 becomes the new root

  4.4 Return the removed node.



Constraints of the testcases:

+ number of operations <= 10^4

+ 1 <= val <= 10^5

For example:

Test	Input	Result

SplayTree tree;
    int query;
    cin >> query;
    for(int i = 0; i < query; i++) {
        string op;
        int val;
        cin >> op >> val;
        if (op == "insert")
            tree.insert(val);
        else if (op == "remove")
            cout << (tree.remove(val) != nullptr ? "removed" : "not found") << '\n';
        else if (op == "search")
            cout << (tree.search(val) ? "found" : "not found") << '\n';
        else if (op == "print")
            tree.printPreorder();
    }
    tree.printBinaryTree();
	7
	insert 100
	insert 300
	insert 200
	insert 50
	insert 250
	remove 200
	print 0
		removed
		100 50 250 300
		└──100
		    ├──50
		    └──250
		        ├──
		        └──300

SplayTree tree;
    int query;
    cin >> query;
    for(int i = 0; i < query; i++) {
        string op;
        int val;
        cin >> op >> val;
        if (op == "insert")
            tree.insert(val);
        else if (op == "remove")
            cout << (tree.remove(val) != nullptr ? "removed" : "not found") << '\n';
        else if (op == "search")
            cout << (tree.search(val) ? "found" : "not found") << '\n';
        else if (op == "print")
            tree.printPreorder();
    }
    tree.printBinaryTree();
	7
	insert 900
	insert 1400
	insert 100
	insert 800
	insert 750
	remove 500
	print 0
		not found
		100 750 800 900 1400
		└──100
		    ├──
		    └──750
		        ├──
		        └──800
		            ├──
		            └──900
		                ├──
		                └──1400

SplayTree tree;
int query;
cin >> query;
for(int i = 0; i < query; i++) {
    string op;
    int val;
    cin >> op >> val;
    if (op == "insert")
        tree.insert(val);
    else if (op == "remove")
        cout << (tree.remove(val) != nullptr ? "removed" : "not found") << '\n';
    else if (op == "search")
        cout << (tree.search(val) ? "found" : "not found") << '\n';
    else if (op == "print")
        tree.printPreorder();
}
	12
	insert 15
	insert 3
	remove 15
	print 0
	insert 5
	insert 1
	remove 1
	insert 5
	insert 9
	insert 3
	insert 13
	print 0
		removed
		3
		removed
		13 3 3 9 5 5

Answer: (penalty regime: 0. %)

Reset answer

```
Node* remove(int val) {
    // Nếu cây rỗng (root == NULL), trả về root
    if (root == NULL) {
        return root;
    }

    // Tìm kiếm node có giá trị bằng val và đưa nó lên làm root
    search(val);
    // Nếu giá trị của root không bằng val, trả về NULL vì val không tồn tại tro
    if (root->val != val) {
        return NULL;
    }

    // Nếu giá trị của root bằng val, ta sẽ tiến hành xóa root khỏi cây
    Node* removedNode = root;
    Node* leftSubtree = root->pLeft;
    Node* rightSubtree = root->pRight;

    // Tách cây thành 2 cây con: cây bên trái (leftSubtree) và cây bên phải (rig
    if (leftSubtree != NULL) {
        leftSubtree->pParent = NULL;
    }
    if (rightSubtree != NULL) {
        rightSubtree->pParent = NULL;
    }

    // Nếu cây bên trái rỗng, cây bên phải sẽ trở thành root mới
    if (leftSubtree == NULL) {
        root = rightSubtree;
    } else {
        // Nếu cây bên trái không rỗng, tìm node có giá trị lớn nhất trong cây b
        root = leftSubtree;
        while (root->pRight != NULL) {
            root = root->pRight;
        }
        splay(root);
        // Đặt cây bên phải làm cây con phải của root mới
```

Precheck Kiểm tra

	Test	Input	Expected	Got	

✓	`SplayTree tree;`
	`int query;`
	`cin >> query;`
	`for(int i = 0; i < query; i++) {`
	`    string op;`
	`    int val;`
	`    cin >> op >> val;`
	`    if (op == "insert")`
	`        tree.insert(val);`
	`    else if (op == "remove")`
	`        cout << (tree.remove(val) != nullptr ? "removed" : "not found") << '\n';`
	`    else if (op == "search")`
	`        cout << (tree.search(val) ? "found" : "not found") << '\n';`
	`    else if (op == "print")`
	`        tree.printPreorder();`
	`}`
	`tree.printBinaryTree();`
		7
		insert
		100
		insert
		300
		insert
		200
		insert 50
		insert
		250
		remove
		200
		print 0
			removed
			100 50 250 300
			└─100
			   ├─50
			   └─250
			      ├─
			      └─300
				removed
				100 50 250 300
				└─100
				   ├─50
				   └─250
				      ├─
				      └─300
					✓

	Test	Input	Expected	Got	

✓	`    SplayTree tree;`
	`    int query;`
	`    cin >> query;`
	`    for(int i = 0; i < query; i++) {`
	`        string op;`
	`        int val;`
	`        cin >> op >> val;`
	`        if (op == "insert")`
	`            tree.insert(val);`
	`        else if (op == "remove")`
	`            cout << (tree.remove(val) != nullptr ? "removed" :`
	`"not found") << '\n';`
	`        else if (op == "search")`
	`            cout << (tree.search(val) ? "found" : "not found") <<`
	`'\n';`
	`        else if (op == "print")`
	`            tree.printPreorder();`
	`    }`
	`    tree.printBinaryTree();`
		`7`
		`insert`
		`900`
		`insert`
		`1400`
		`insert`
		`100`
		`insert`
		`800`
		`insert`
		`750`
		`remove`
		`500`
		`print 0`
			`not found`
			`100 750 800 900`
			`1400`
			`└─100`
			`   ├─`
			`   └─750`
			`      ├─`
			`      └─800`
			`         ├─`
			`         └─900`
			`            ├─`
			
			`└─1400`
				`not found`
				`100 750 800 900`
				`1400`
				`└─100`
				`   ├─`
				`   └─750`
				`      ├─`
				`      └─800`
				`         ├─`
				`         └─900`
				`            ├─`
				
				`└─1400`
					✓

Passed all tests! ✓