CSE225L – Data Structures and Algorithms Lab
Lab 12
Binary Search Tree

In today's lab we will design and implement the Binary Search Tree ADT.

binarysearchtree.h

```
#ifndef BINARYSEARCHTREE_H_INCLUDED
#define BINARYSEARCHTREE_H_INCLUDED
#include "quetype.h"
template <class ItemType>
struct TreeNode
{
    ItemType info;
    TreeNode* left;
    TreeNode* right;
};
enum OrderType {PRE_ORDER, IN_ORDER,
POST_ORDER};
template <class ItemType>
class TreeType
{
    public:
        TreeType();
        ~TreeType();
        void MakeEmpty();
        bool IsEmpty();
        bool IsFull();
        int LengthIs();
        void RetrieveItem(ItemType& item,
bool& found);
        void InsertItem(ItemType item);
        void DeleteItem(ItemType item);
        void ResetTree(OrderType order);
        void GetNextItem(ItemType& item,
OrderType order, bool& finished);
        void Print();
    private:
        TreeNode<ItemType>* root;
        QueType<ItemType> preQue;
        QueType<ItemType> inQue;
        QueType<ItemType> postQue;
};
#endif // BINARYSEARCHTREE_H_INCLUDED
```

binarysearchtree.cpp

```
#include "binarysearchtree.h"
#include "quetype.cpp"
#include <iostream>
using namespace std;
template <class ItemType>
TreeType<ItemType>::TreeType()
{
    root = NULL;
}
template <class ItemType>
void Destroy(TreeNode<ItemType>*& tree)
{
    if (tree != NULL)
    {
        Destroy(tree->left);
        Destroy(tree->right);
        delete tree;
        tree = NULL;
    }
}
template <class ItemType>
TreeType<ItemType>::~TreeType()
{
    Destroy(root);
}
template <class ItemType>
void TreeType<ItemType>::MakeEmpty()
{
    Destroy(root);
}
template <class ItemType>
bool TreeType<ItemType>::IsEmpty()
{
    return root == NULL;
}
template <class ItemType>
bool TreeType<ItemType>::IsFull()
{
    TreeNode<ItemType>* location;
    try
    {
        location = new TreeNode<ItemType>;
        delete location;
        return false;
    }
    catch(bad_alloc& exception)
    {
        return true;
    }
}
template <class ItemType>
int CountNodes(TreeNode<ItemType>* tree)
{
    if (tree == NULL)
        return 0;
    else
        return CountNodes(tree->left) +
CountNodes(tree->right) + 1;
}
template <class ItemType>
int TreeType<ItemType>::LengthIs()
{
    return CountNodes(root);
}
template <class ItemType>
void Retrieve(TreeNode<ItemType>* tree, ItemType&
item, bool& found)
{
    if (tree == NULL)
        found = false;
    else if (item < tree->info)
        Retrieve(tree->left, item, found);
    else if (item > tree->info)
        Retrieve(tree->right, item, found);
    else
    {
        item = tree->info;
        found = true;
    }
}
template <class ItemType>
void TreeType<ItemType>::RetrieveItem(ItemType&
item, bool& found)
{
    Retrieve(root, item, found);
}
```

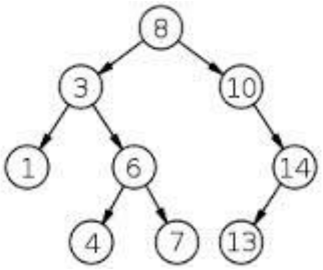
```
template <class ItemType>
void Insert(TreeNode<ItemType>*& tree,
ItemType item)
{
    if (tree == NULL)
    {
        tree = new TreeNode<ItemType>;
        tree->right = NULL;
        tree->left = NULL;
        tree->info = item;
    }
    else if (item < tree->info)
        Insert(tree->left, item);
    else
        Insert(tree->right, item);
}
template <class ItemType>
void TreeType<ItemType>::InsertItem(ItemType
item)
{
    Insert(root, item);
}
template <class ItemType>
void Delete(TreeNode<ItemType>*& tree,
ItemType item)
{
    if (item < tree->info)
        Delete(tree->left, item);
    else if (item > tree->info)
        Delete(tree->right, item);
    else
        DeleteNode(tree);
}
template <class ItemType>
void DeleteNode(TreeNode<ItemType>*& tree)
{
    ItemType data;
    TreeNode<ItemType>* tempPtr;

    tempPtr = tree;
    if (tree->left == NULL)
    {
        tree = tree->right;
        delete tempPtr;
    }
    else if (tree->right == NULL)
    {
        tree = tree->left;
        delete tempPtr;
    }
    else
    {
        GetPredecessor(tree->left, data);
        tree->info = data;
        Delete(tree->left, data);
    }
}
template <class ItemType>
void GetPredecessor(TreeNode<ItemType>*
tree, ItemType& data)
{
    while (tree->right != NULL)
        tree = tree->right;
    data = tree->info;
}
template <class ItemType>
void TreeType<ItemType>::DeleteItem(ItemType
item)
{
    Delete(root, item);
}
```

```
template <class ItemType>
void PreOrder(TreeNode<ItemType>* tree,
QueType<ItemType>& Que)
{
    if (tree != NULL)
    {
        Que.Enqueue(tree->info);
        PreOrder(tree->left, Que);
        PreOrder(tree->right, Que);
    }
}
template <class ItemType>
void InOrder(TreeNode<ItemType>* tree,
QueType<ItemType>& Que)
{
    if (tree != NULL)
    {
        InOrder(tree->left, Que);
        Que.Enqueue(tree->info);
        InOrder(tree->right, Que);
    }
}
template <class ItemType>
void PostOrder(TreeNode<ItemType>* tree,
QueType<ItemType>& Que)
{
    if (tree != NULL)
    {
        PostOrder(tree->left, Que);
        PostOrder(tree->right, Que);
        Que.Enqueue(tree->info);
    }
}
template <class ItemType>
void TreeType<ItemType>::ResetTree(OrderType
order)
{
    switch (order)
    {
        case PRE_ORDER:
            PreOrder(root, preQue);
            break;
        case IN_ORDER:
            InOrder(root, inQue);
            break;
        case POST_ORDER:
            PostOrder(root, postQue);
            break;
    }
}
template <class ItemType>
void TreeType<ItemType>::GetNextItem(ItemType&
item, OrderType order, bool& finished)
{
    finished = false;
    switch (order)
    {
        case PRE_ORDER:
            preQue.Dequeue(item);
            if(preQue.IsEmpty())
                finished = true;
            break;
        case IN_ORDER:
            inQue.Dequeue(item);
            if(inQue.IsEmpty())
                finished = true;
            break;
        case POST_ORDER:
            postQue.Dequeue(item);
            if(postQue.IsEmpty())
                finished = true;
            break;
    }
}
```

```
template <class ItemType>
void PrintTree(TreeNode<ItemType>* tree)
{
    if (tree != NULL)
    {
        PrintTree(tree->left);
        cout << tree->info << " ";
        PrintTree(tree->right);
    }
}
template <class ItemType>
void TreeType<ItemType>::Print()
{
    PrintTree(root);
}
```

Now generate the **Driver file (main.cpp)** where you perform the following tasks:

Operation to Be Tested and Description of Action	**Input Values**	**Expected Output**
• Create a tree object		
• Print if the tree is empty or not		Tree is empty
• Insert ten items	4 9 2 7 3 11 17 0 5 1	
• Print if the tree is empty or not		Tree is not empty
• Print the length of the tree		10
• Retrieve 9 and print whether found or not		Item is found
• Retrieve 13 and print whether found or not		Item is not found
• Print the elements in the tree (inorder)		0 1 2 3 4 5 7 9 11 17
• Print the elements in the tree (preorder)		4 2 0 1 3 9 7 5 11 17
• Print the elements in the tree (postorder)		1 0 3 2 5 7 17 11 9 4
• Make the tree empty		
• Build the following tree inserting the elements, one by one  		
• Add a member function to the TreeType class which returns the minimum element in the tree. `int findMin();`		1
• Add a function to the TreeType class which returns the number of leaves in the tree. `int numLeaves();`		4