EE2410 Data Structure Coding HW #4 -- Trees (Chapter 5)
due date 5/26/2024, 23:59
You should submit:
(a) All your source codes (C++ file).
(b) Show the execution trace of your program, i.e., write a client main() to demonstrate all functions you designed using example data.

Submit your homework before the deadline (midnight of 5/26). Fail to comply (**late** homework) will have ZERO score. **Copy** homework will have ZERO score on both parties and SERIOUS consequences.

1. (40%) Binary tree

Develop a complete C++ template class for binary trees shown below.

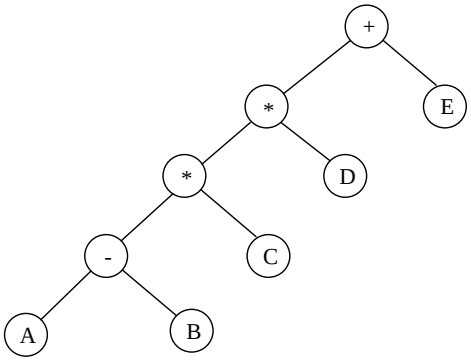
```
template <class T> class Tree;
template <class T>
class TreeNode {
friend class Tree <T>;
friend class InorderIterator<T>;//inorder iterator
private:
    T data;
    TreeNode <T> *leftChild;
    TreeNode <T> *rightChild;
};

template<class T>
class Tree
{
friend class InorderIterator<T>;//inorder iterator
public:
    Tree(); // constructor for an empty binary tree
    Tree(Tree<T>& bt1, T& item, Tree<T>& bt2);
    Tree(const Tree<T>&); //copy constructor
    // constructor given the root item and left subtrees bt1 and right subtree bt2
    ~Tree();
    bool IsEmpty(); // return true iff the binary tree is empty
    Tree<T> LeftSubtree(); // return the left subtree
    Tree<T> RightSubtree();// return the right subtree
```

```
        T RootData();    // return the data in the root node of *this
        // more operations
    private:
        TreeNode <T> *root;
        void Visit(TreeNode<T> *p){cout << p->data << "    ";}
};
template <class T>
class InorderIterator{
public:
        InorderIterator(){ currentNode = root;} // Constructor
        InorderIterator(Tree<T> tree):t(tree){ currentNode = t.root; }
        T* Next();
        T& operator *();
        bool    operator!=(const InorderIterator r)
private:
        Tree<T> t;
        Stack<TreeNode<T>*> s;
        TreeNode<T> * currentNode;
};
```

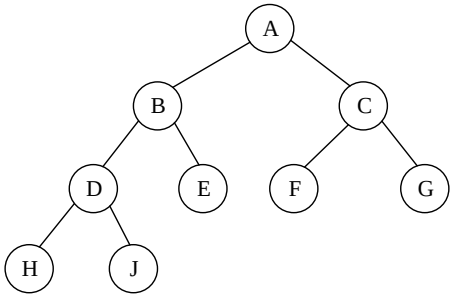
You must include a **constructor**, **copy constructor**, **destructor**, the traversal methods and operator overloads and the iterator class as shown below, and functions in **ADT 5.1**.

```
void Inorder()
void Preorder()
void Postorder()
void LevelOrder()
void NonrecInorder()
void NoStackInorder()
bool operator == (const Tree& t);
TreeNode<T> * Copy(TreeNode<T> * p); // Workhorse
bool Equal(const Tree<T>& t);
bool Equal(TreeNode<T>* a , TreeNode<T>* b);
void setup1();
void setup2();
void output();
```

Write 2 setup and display functions to establish and display 2 example binary trees shown below. Then **demonstrate** the functions you wrote.



(a)



(b)

Result:

```
C:\c++\data_structure\hw4\fi
Ex1 :
        +
       / \
      *   E
     / \
    *   D
   / \
  -   C
 / \
A   B

The tree is not empty

The root data is +
Print the tree in Preorder : + * * - A B C D E
Print the tree in Inorder : A - B * C * D + E
Inorder traversal using iterator: A - B * C * D + E
Print the tree in Posorder : A B - C * D * E +
Print the tree in LevelOrder : + * E * D - C A B
Print the left subtree using NonrecInorder : A - B * C * D
Print the left subtree using NoStackInorder : E
The left subtree is not equal to the right subtree

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Ex2 :
          A
         / \
        /   \
       B     C
      / \   / \
     D   E F   G
    / \
   H   J

The tree is not empty

The root data is A
Print the tree in Preorder : A B D H J E C F G
Print the tree in Inorder : H D J B E A F C G
Inorder traversal using iterator: H D J B E A F C G
Print the tree in Posorder : H J D E B F G C A
Print the tree in LevelOrder : A B C D E F G H J
Print the left subtree using NonrecInorder : H D J B E
Print the left subtree using NoStackInorder : F C G
The left subtree is not equal to the right subtree
Process returned 0 (0x0)   execution time : 0.036 s
Press any key to continue.
```

2. (20%) Threaded binary tree

Write a C++ template class for threaded binary trees: ThreadedTree according to the tree node structure as shown in Figure 5.21 in textbook. Then write C++ functions for:

(a) Forward iterator by sequencing through the nodes in inorder.

(b) Traverse a threaded binary tree in postorder.

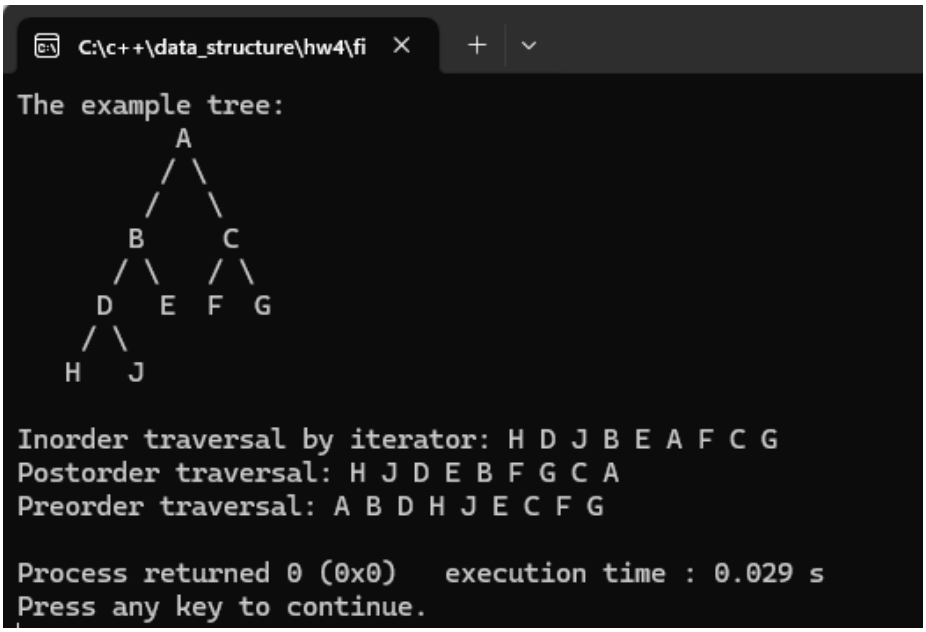
(c) Traverse a threaded binary tree in preorder.

(d) Insert a new node r as the right child of node s in a threaded binary tree.

(e) Insert a new node l as the left child of node s in a threaded binary tree.

Use binary tree (b) shown above as example to construct a threaded binary tree and demonstrate the above five functions you implemented.

Result:



3. (20%)

(a) Write a C++ class MaxHeap that derives from the abstract base class in **ADT 5.2 MaxPQ** and implement all the virtual functions of MaxPQ.

```
ADT 5.2 MaxPQ
template <class T>
class MaxPQ {
public:
    virtual ~MaxPQ() {}    // virtual destructor
    virtual bool IsEmpty() const = 0; //return true iff empty
    virtual const T& Top() const = 0; //return reference to the max
    virtual void Push(const T&) = 0;
    virtual void Pop() = 0;
```

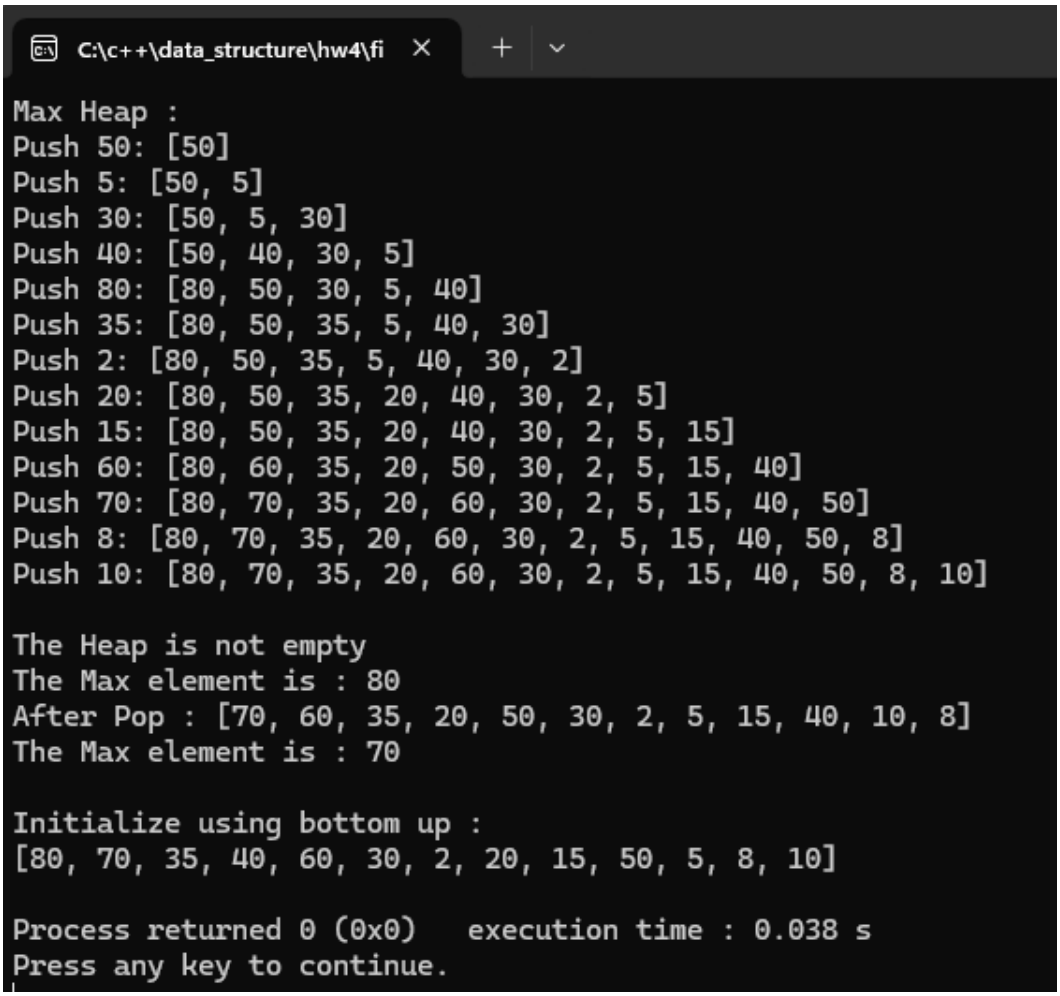
};

The class MaxHeap should include a **bottom up heap construction initialization** function, the push function for inserting a new key and pop function for deleting and the max key. You should also write a client function (main()) to demonstrate how to construct a max heap from a sequence of 13 integer number: 50, 5, 30, 40, 80, 35, 2, 20, 15, 60, 70, 8, 10 by using a series of 13 pushes and by bottom up initialization. Add necessary code for displaying your result.

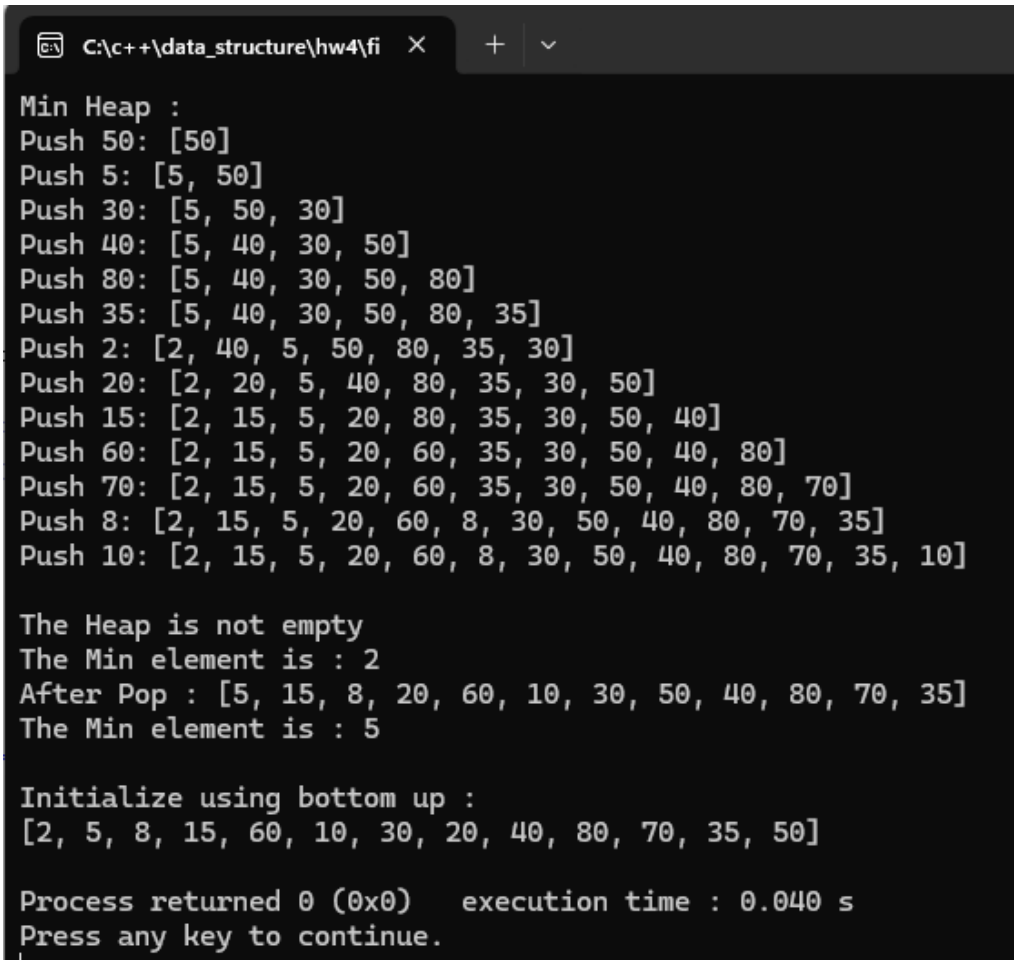
(b) Write a C++ abstract class similar to ADT 5.2 for the ADT **MinPQ**, which defines a min priority queue. Then write a C++ class MinHeap that derives from this abstract class and implement all the virtual functions of MinPQ.
The class MinHeap should include a **bottom up heap construction initialization** function, the push function for inserting a new key and pop function for deleting and the min key. You should also write a client function (main()) to demonstrate how to construct a min heap from a sequence of 13 integer number: 50, 5, 30, 40, 80, 35, 2, 20, 15, 60, 70, 8, 10 by using a series of 13 pushes and by bottom up initialization. Add necessary code for displaying your result.

Result:

(a)



(b)



4. (20%)

A Dictionary abstract class is shown in **ADT5.3 Dictionary**. Write a C++ class BST that derives from Dictionary and implement all the virtual functions. In addition, also implement

Pair<K, E>* RankGet(**int** r),

void Split(**const** K& k, BST<K, E>& small, pair<K, E>*& mid, BST<K, E>& big)

ADT5.3 Dictionary

```
template <class K, class E>
class Dictionary {
public:
    virtual bool IsEmptay() const = 0;    // return true if dictionary is empty
    virtual pair <K, E>* Get(const K&) const = 0;
    // return pointer to the pair w. specified key
    virtual void Insert(const Pair <K, E>&) = 0;
    // insert the given pair; if key ia a duplicate, update associate element
```

```
    virtual void Delete(const K&) = 0;    // delete pair w. specified key
};
```

Use a sequence of 13 integer number: 50, 5, 30, 40, 80, 35, 2, 20, 15, 60, 70, 8, 10 as 13 key values (type int) to generate 13 (key, element) (e.g., element can be simple char) pairs to construct the BST. Demonstrate your functions using this set of records.

Result: