Project #3 - Indexing with AVL Trees

Learning Objectives

- Demonstrate effective use of memory management techniques in C++
- Implement a data structure to meet given specifications
- Design, implement, and use an AVL tree data structure
- Analyze operations for time complexity

Overview

Your task for this assignment is to implement an AVL tree that serves as a *map* data type. A map allows you to store and retrieve key/value pairs. For this project, the key will be an integer and the value will be a string.

The AVLTree Class

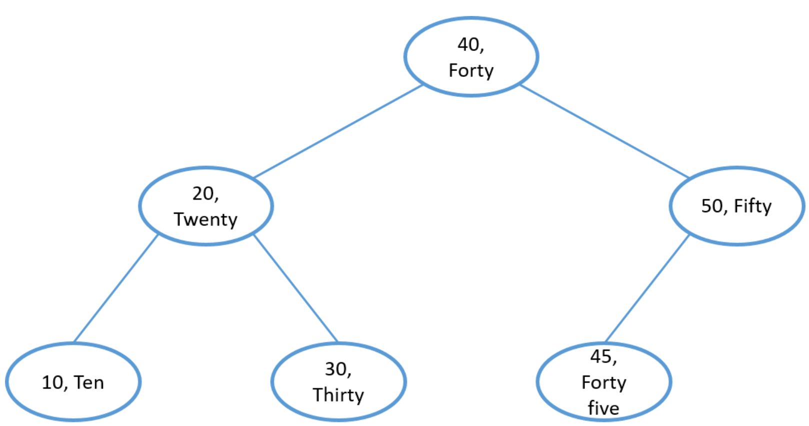
The map will be implemented as an AVL tree. For this project, you must write your own AVL tree - not using code from outside sources. Your AVL tree should remain balanced by implementing single and double rotations when inserting new data. Your tree must support the following operations:

- `bool AVLTree::insert(int key, int value)` – Insert a new key/value pair into the tree. For this assignment the duplicate keys are not allowed. This function should return **true** if the key/value pair is successfully inserted into the map, and **false** if the pair could not be inserted (for example, due to a duplicate key already found in the map).

- `int AVLTree::getHeight()` – return the height of the AVL tree.

- `int AVLTree::getSize()` – return the total number of nodes (key/value pairs) in the AVL tree.

- `friend ostream& operator<<(ostream& os, const AVLTree& me)` - print the tree using the << operator. You should overload the << operator to print the AVL tree "sideways" using indentation to show the structure of the tree. For example, consider the following AVL tree (each node contains a key, value pair):



This tree would be printed as follows:

```
        50, Fifty
               45, Forty five
40, Forty
               30, Thirty
        20, Twenty
               10, Ten
```

(*Note: If you turn your head sideways, you can see how this represents the tree.*)
(*Also note: This style of printout can be directly implemented as a right-child-first inorder traversal of the tree.*)

- `bool AVLTree::find(int key, string& value)` – if the given key is found in the AVL tree, this function should return **true** and place the corresponding value in **value**. Otherwise this function should return **false** (and the value in **value** can be anything).

- `vector<string> AVLTree::findRange(int lowkey, int highkey)` – this function should return a C++ vector of strings containing all of the values in the tree with keys ≥ lowkey and ≤ highkey. For each key found in the given range, there will be one value in the vector. If no matching key/value pairs are found, the function should return an empty vector.

  Example: Suppose the call `resultVector = myTree.findRange(30, 47)` were called on the tree pictured above. The findRange function would then return a vector containing the strings: {"Thirty", "Fourty", "Forty five"}.

Turn in and Grading

- The AVLTree class should use a seperate AVLTree.h and AVLTree.cpp file.
- Please zip your entire project directory into a single file called Project3_YourLastName.zip.

This project is worth 50 points, distributed as follows:

Task	Points
`AVLTree::insert` stores key/value pairs in the correct locations in the AVLTree, and correctly rejects duplicate keys	5
`AVLTree::getHeight()` correctly returns the height of the tree	3
The tree maintains correct balance, regardless of the order in which keys are inserted	10
`AVLTree::getSize()` correctly returns the number of key/value pairs in the tree	3
`operator<<` prints the tree in a neat and readable manner, using indentation or some other appropriate mechanism to clearly show the structure of the tree	4
`AVLTree::find` correctly finds and returns key/value pairs in the tree in Θ(log *n*) time, and returns **false** when no matching key is found	5

`AVLTree::findRange` correctly returns a C++ vector of strings matching keys in the specified range	10
Code is well organized, well documented, and properly formatted. Variable names are clear, and readable. Classes are declared and implemented in seperate (.cpp and .h) files.	10