

## CMSC 132 Quiz 4 Worksheet

The fourth quiz for the course will be on Wed, Dec. 1. The following list provides additional information about the quiz:

- The quiz will be a written quiz (no computer).
- **The quiz will be in lab / discussion session.**
- Closed book, closed notes quiz.
- Answers must be neat and legible.
- The quiz has a maximum duration of 25 minutes.
- Make sure you know your section number and your discussion TA's name. Bring your student id.
- You must take your quiz in your assigned lab / discussion session and not show up to a random one. We will not grade quizzes taken in the incorrect section.
- Please do not discuss a quiz after you have taken it.
- Piazza will be closed on days quizzes take place.
- **Regarding Piazza** - Feel free to post questions in Piazza regarding the worksheet and possible solutions to problems.

**The following exercises gives you practice with concepts that may show up on the quiz.** Solutions to these exercises will not be provided, but you are welcome to discuss your solutions with the TAs during office hours. It is recommended that you try these exercises on paper first (without using a computer).

Some recursion problems require an auxiliary method. For example, a recursive implementation for the tree size() method may use an auxiliary method that takes as parameter a reference to a Node. Keep this in mind while solving the problems below.

The following Java class definition for a binary search tree will be used to answer the questions that follow. We use null to represent an empty tree. For example, an empty BinarySearchTree has a null root, and a leaf node has null left and right fields. You may not add any variables (instance or static) to the class in order to answer the questions below.

```
public class BinarySearchTree <K extends Comparable<K>, V> {
    private class Node {
        private K key;
        private V data;
        private Node left, right;
        public Node(K key, V data) {
            this.key = key;
            this.data = data;
        }
    }

    private Node root;
}
```

1. Define a constructor that creates an empty tree.
2. Define a recursive method **add(K key, V data)** that adds a key,value pair to the proper location in the tree.
3. Define a recursive method **size()** that returns the number of entries in the tree.
4. Define a **non-recursive** method **max()** that returns the data associated with the maximum key value in the tree.
5. Define a **recursive** method **max()** that returns the data associated with maximum key value in the tree.
6. Define a recursive method **min()** that returns the data associated with minimum key value in the tree.
7. Define a recursive method named **postOrderTraversal()** which returns a string representing a post-order traversal of the tree.
8. Define a recursive method **getNumInteriorNodes()** that returns the number of non-leaf nodes in the tree.
9. Define a recursive method **getHeight()** that returns the height of the tree.
10. Define a recursive method **leaves(ArrayList<K> L)** that adds to the ArrayList L, the key value of leaf nodes.
11. Define a recursive method **getDecreasingOrderList()** that returns an ArrayList with the data elements of the tree inserted into the list based on decreasing key order.
12. Define a **recursive** method **getDataOneChildNodes(ArrayList<V> L)** that adds to the ArrayList argument the **data** of nodes in the tree that have only one child. Add the elements to the ArrayList in any order. You must use an auxiliary function.
13. Define a recursive method that places the keys and values of a Tree into a Java TreeMap.
14. **Review the slides and examples on the slide set about binary heaps.**

Here is some old material on binary heaps and BST. On the old exam 3, just focus on the heap and BST problem.

<http://www.cs.umd.edu/class/fall2021/cmsc132-030X/quizzes/OldQuiz4Material.zip>