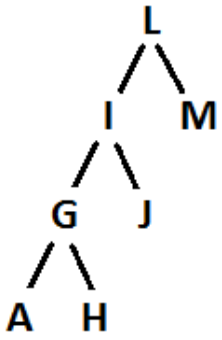
CSC 300 Sections 402, 411, 701, 710 Fall 2017
Homework assignment 3
Due: as specified on D2L

Note: This is a written assignment. You must upload your solutions onto D2L. You have many options, among which are:

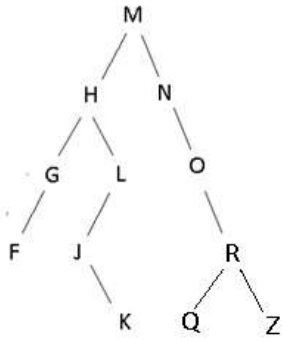
- Use an application that enables you to draw trees on an electronic device.
- Write out your answers on paper, and scan them or take pictures of them

The assignment is worth 5 points, or 5% of your total grade. There are 10 problems, each worth .5 point, and one extra credit problem.

Part 1: Binary Search Trees



(a)



(b)

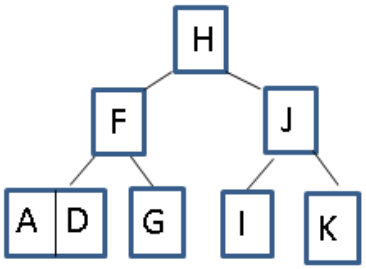
1. Considering binary search tree (a), give (i) the root, (ii) the root's children, (iii) the leafs, (iv) the depth of the each leaf, (v) the height of I, and (vi) the height of the tree.

2. Show the state of tree (a) after the following sequence of items have been added: **E, N, O, D, C.** You have a choice between drawing just one tree which results from the entire sequence of insertions (which should have 12 nodes), or drawing up to 5 trees which reflect intermediate results.

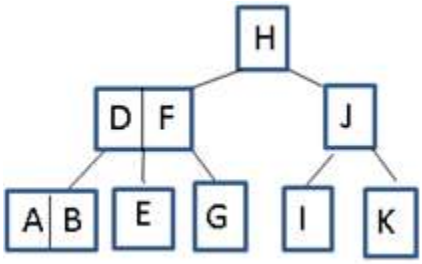
3. Show the state of tree (b) after the following sequence of items have been removed: **G, H, J, N, M**. You have a choice between drawing just one tree which results from the entire sequence of deletions (the tree should have 7 nodes left), or drawing up to 5 trees which reflect intermediate results.

Part 2: Two-three trees

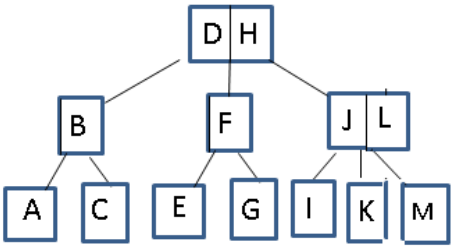
1. Draw the tree that results from adding **E** to the 2-3 tree shown below.



2. Draw the tree that results from adding **C** to the 2-3 tree shown below.



3. Draw that tree that results from adding **O** and **P** in sequence to the 2-3 tree shown below.



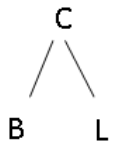
Part 3: Red-black trees

Left-leaning red-black trees, as they are described in the Sedgewick and Wayne text, undergo 3 possible transformations as they grow: **rotateLeft**, **rotateRight**, and **flipColors**. You may refer to the text or my lecture notes for the details of each of these tree transformations.

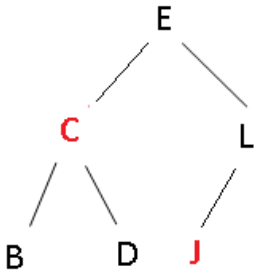
In red-black tree diagrams, you will see 2 ways to represent color. In the first, edges are colored, either red or black. In the other version, color information is stored within each node, and edges are not colored. In this second version, the root of the tree is always black. We will use the second version, in which nodes have color, to draw red-black trees.

1. Draw the red-black tree that is equivalent to the 2-3 tree from problem 3 of the last section, **prior** to the insertions of **O** and **P**.

2. Show the results of adding **E** and then **D** to the tree below. If you wish, you may draw intermediate trees, showing the transformations that occur. Or, you may draw just 1 tree, reflecting the final state of the tree after both insertions are complete.



3. Show the results of adding **K** to the tree below. If you wish, you may draw intermediate trees, showing the transformations that occur.



4. Draw the 2-3 tree that is equivalent to the last red-black tree you drew for problem 3.

5. (1 point extra credit) Draw the red-black tree that results from removing **4, 9,** and **7** in sequence from the red-black tree below. You may draw intermediate trees if you wish to show removals of individual numbers and/or tree transformations along the way. Or, you may draw the final tree after the entire sequence of removals.

   All of the nodes in the tree below are initially black.