3) (10 pts) ALG (AVL Trees)
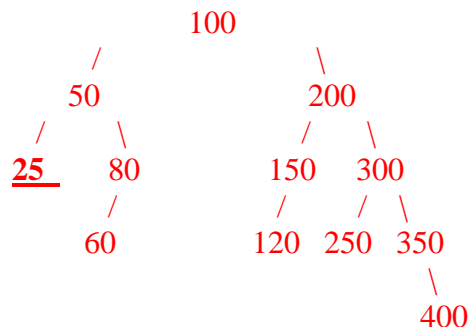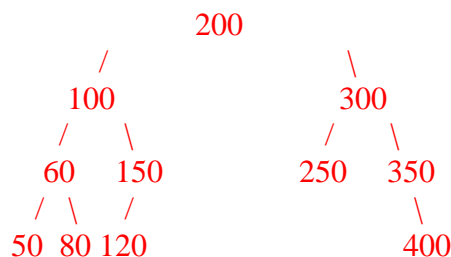
Draw an AVL tree **of integers** and designate a single node in the AVL tree such that, if that node were to be deleted, two rebalance operations (not one double rotation, but two separate operations and two different nodes) would occur. Clearly label the node to delete which would precipitate those operations and show the result of deleting that node. (Thus, you should have two drawings, a before drawing of the original tree with the node to be deleted clearly designated, and an after drawing showing what the tree looks like after the node is deleted and goes through 2 rebalance operations.)

There are many, many solutions, perhaps the easiest to visualize is where one side of the tree is short and the other is tall. To force 2 rebalance operations, the tree must be a height of at least 4, with one subtree height 2 and the other height 3. The height 2 subtree has to rebalance to a height 1 subtree to force the second restructure. In this solution, the tree is "right" heavy:

```
                        100
                   /           \
                 50             200
               /    \          /    \
             25     80       150    300
                    /        /      /   \
                  60       120    250   350
                                          \
                                          400
```

Deleting 25 from this AVL tree will cause a rebalance at 50 AND a rebalance at 100. Here is the resulting tree after deleting 25:

```
                       200
                  /            \
               100             300
              /    \          /    \
            60     150      250    350
           / \     /                 \
         50  80  120                 400
```

Grading: 3 pts drawing a valid AVL tree BEFORE deletion,
**   1 pt to clearly indicate a node to delete,**
**   3 pts if delete causes 2 rebalances, 1 pt if it causes 1 rebalance, 0 pts if no rebalances**
**   3 pts for tree after deletion, grader decides partial.**

If the tree is not a valid AVL tree, automatically 0/10.
If everything is good except there's only 1 rebalance 8/10.
If everything is good except there is no rebalance 5/10 since the deletion is easier.

Computer Science Foundation Exam

August 28, 2021

Section II A

ALGORITHMS AND ANALYSIS TOOLS

SOLUTION

**NO books, notes, or calculators may be used,
and you must work entirely on your own.**

Question #	Max Pts	Category	Score
1	10	ANL	
2	10	ANL	
3	5	ANL	
TOTAL	25		

You must do all 3 problems in this section of the exam.

Problems will be graded based on the completeness of the solution steps and **not** graded based on the answer alone. Credit cannot be given unless all work is shown and is readable. Be complete, yet concise, and above all **be neat**. For each coding question, assume that all of the necessary includes (stdlib.h, stdio.h, math.h, string.h) for that particular question have been made.