COS 226 Fall 2013 Midterm Exam 1 60 pts.; 60 minutes; 6 questions; 8 pages. 2013-10-10 2:00 p.m.

Name: _____

1. (1 pt.)

   - **Read all material carefully.**
   - You may refer to your books, papers, and notes during this test.
   - No computer or network access of any kind is allowed (or needed).
   - Write, and draw, carefully. Ambiguous or cryptic answers receive zero credit.
   - Use the conventions used in class and the textbook for notation, algorithmic options, etc.

   Write your name in the space provided above.

2. (14 pts.) Depict the sequence of AA-tree states resulting from the insertion of the following keys, in the order presented, into an initially empty tree.

   $$20, 18, 16, 14, 12, 13, 15, 10, 8, 6$$

   You must depict intermediate tree states, including the state after each insertion, clearly marking and identifying each skew and split operation. Ensure that horizontal and vertical links are drawn clearly and with arrows.

[additional space for answering the earlier question]

3. (10 pts.) Depict the result of deleting the following keys, in the order presented, from the final tree of Question 2.

$$12, 20, 8, 6, 15$$

As before, depict the state of the tree after each deletion and clearly mark and identify each split and skew operation.

4. (10 pts.) Repeat Question 2 for bottom-up red-black trees, clearly marking and identifying each rotation. Follow the graphical conventions used in class: round nodes for red and boxed nodes for black.

[additional space for answering the earlier question]

5. (15 pts.) Depict the result of inserting the following keys, in the order presented, into an initially empty B-tree with parameters $M = 5$ and $L = 3$, based on the definitions and methods in the textbook. (The tree is thus a B^+-tree.)

$$50, 60, 70, 55, 80, 90, 56, 74, 72, 20, 10, 15$$

Depict enough intermediate states of the tree to make the correctness of the operations evident, including at least the states after each node-splitting operation.

[additional space for answering the earlier question]

6. (10 pts.) Depict the result of deleting the following keys, in the order presented, from the final tree of Question 5.

$$55, 56, 72, 74, 15$$

As before, depict enough intermediate states of the tree to make the correctness of the operations evident, including at least the states after each node-merging operation.