# Department of Computer Science and Engineering
National Sun Yat-sen University
Data Structures Quiz, Chapters 10 and 11, Dec. 16, 2024

1. (a) Please present the definition of an AVL tree. (10%)
   (b) Starting with an empty AVL tree, suppose the key insertion sequence is 18, 30, 50, 14, 13, 16, 60. Draw the AVL tree after each insertion. (25%)

2. (a) A red-black tree is a binary search tree in which every node is colored either red or black. There are three important properties for the colors of the nodes. Please give the three properties for node definition. (10%)
   (b) Starting with an empty red-black tree, suppose the key insertion sequence is 30, 20, 8, 40, 60, 70, 3. Draw the red-black tree after each insertion, and indicate the node colors (R for red, and B for black). (25%).

3. Please draw the tree after 482 and 518 are inserted into the following B-tree of order 5. (15%)
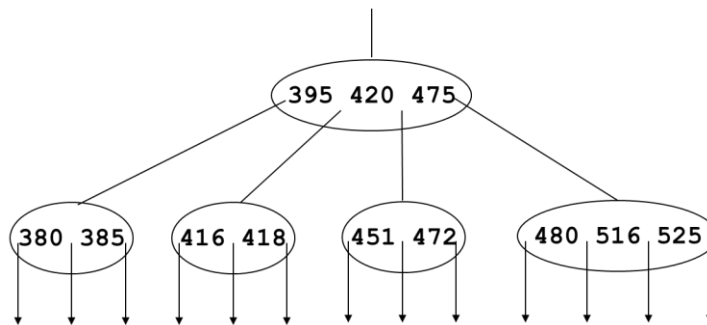
4. Please draw the tree after 173 is deleted from the following B-tree of order 5. (15%)
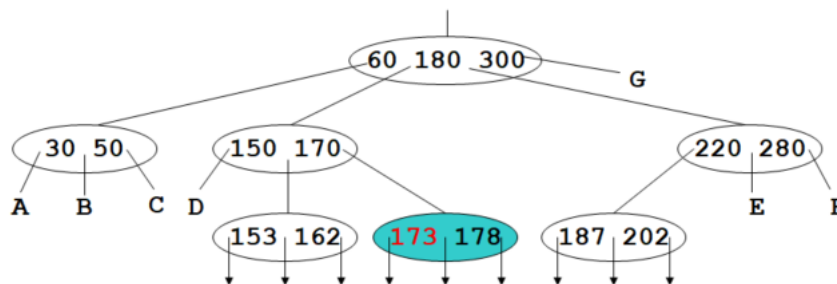
解答

1.

(a)

Height balanced binary search trees, aim to maintain balance while being built, using the balance factor and rotations.

Balance Factor: $BF(v) = h_L - h_R = -1, 0,$ or 1

(h_L / h_R: Height of the left/right subtree.)

----- for more details--------

If BF(v) != -1, 0, or 1, it means the tree is unbalanced, and needs rotation to become balance again. The four types of rotations are listed below.

LL: a right rotation on the root.

RR: a left rotation on the root.

LR: a left rotation on the left child, and then a right rotation on the root.

RL: a right rotation on the right child, and then a left rotation on the root.
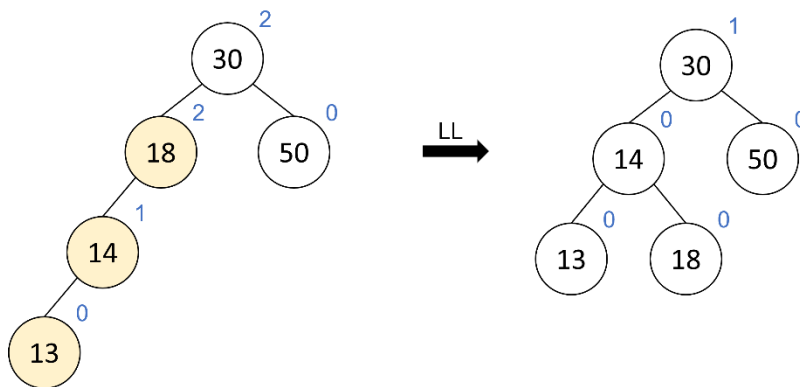
(b)

1. Insert 18

2. Insert 30
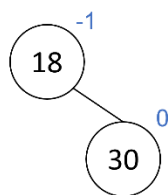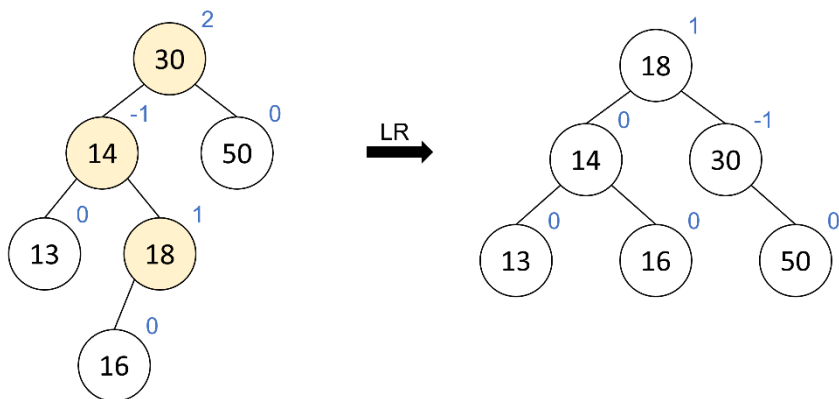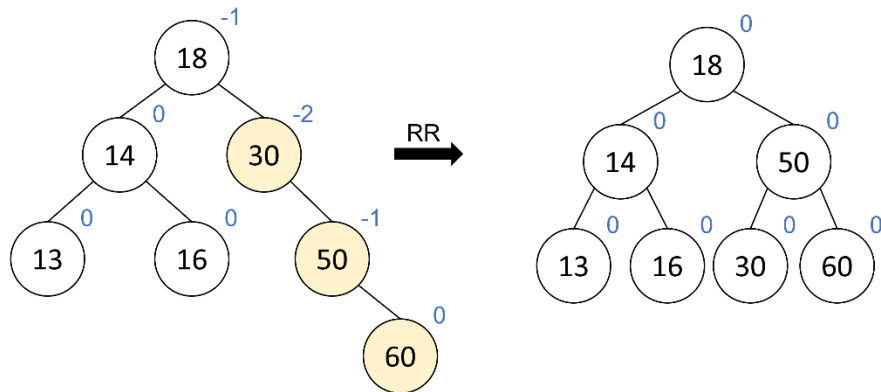

3. Insert 50
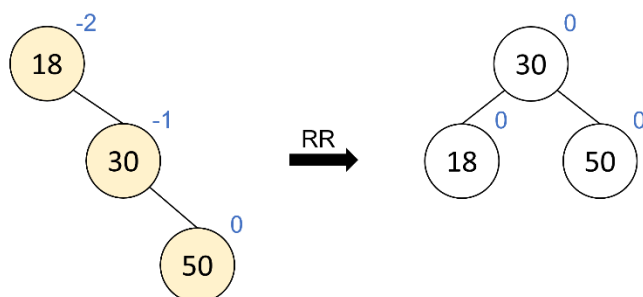
4. Insert 14
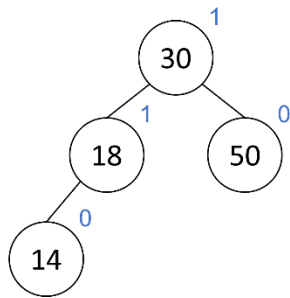
5. Insert 13

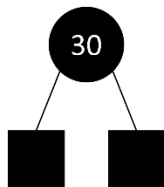# 6. Insert 16

7. Insert 60

2.

(a)

RB1: The root and all external nodes are black.

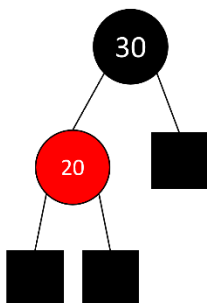RB2: No root-to-external-node path has two consecutive red nodes.

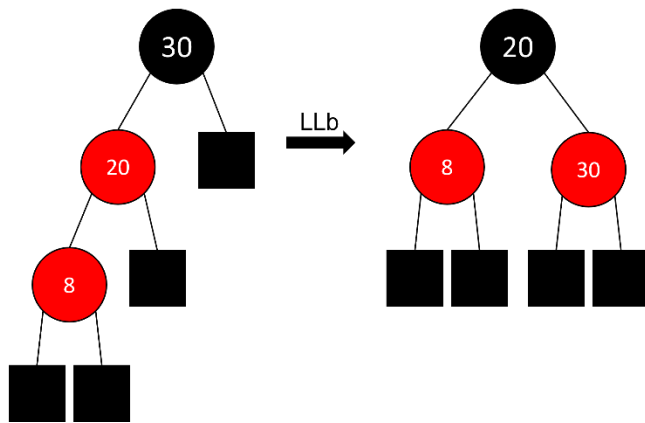RB3: All root-to-external-node paths have the same number of black nodes.
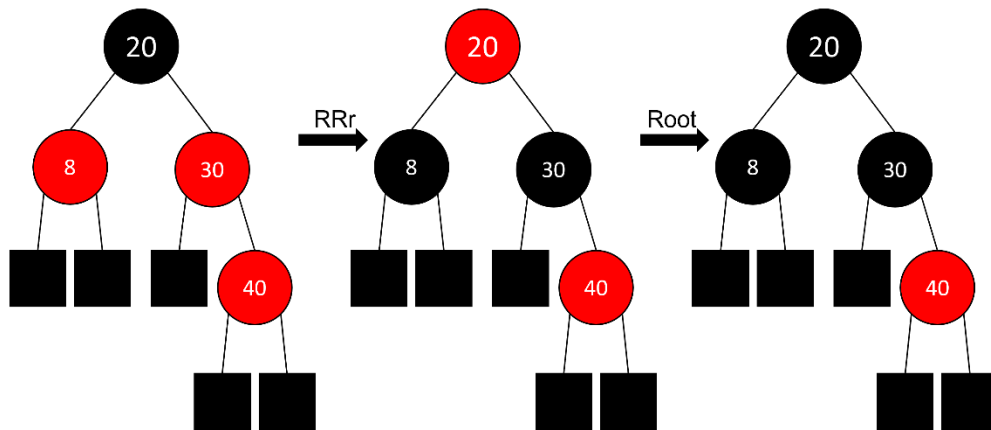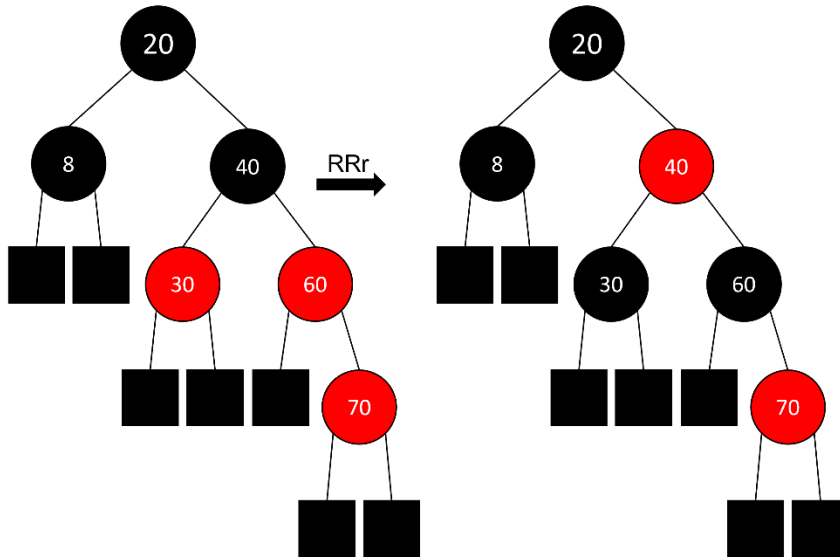
(b)

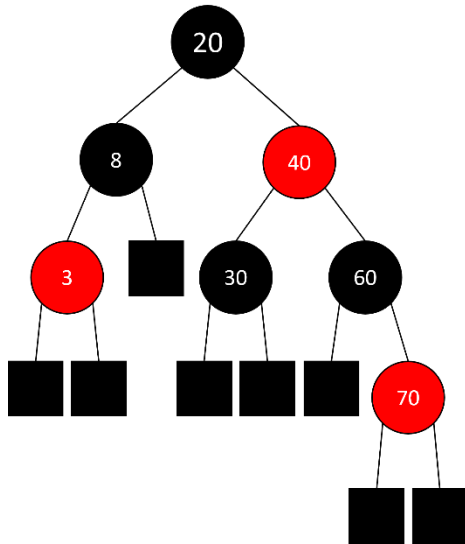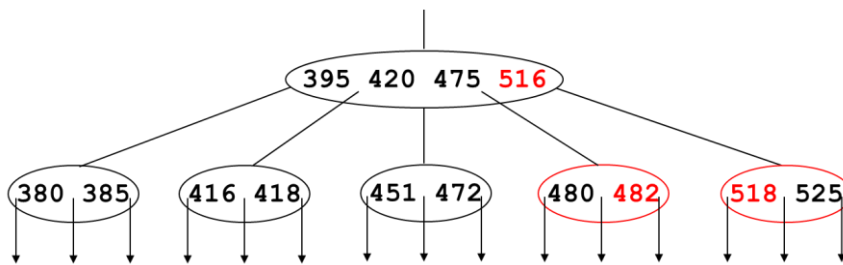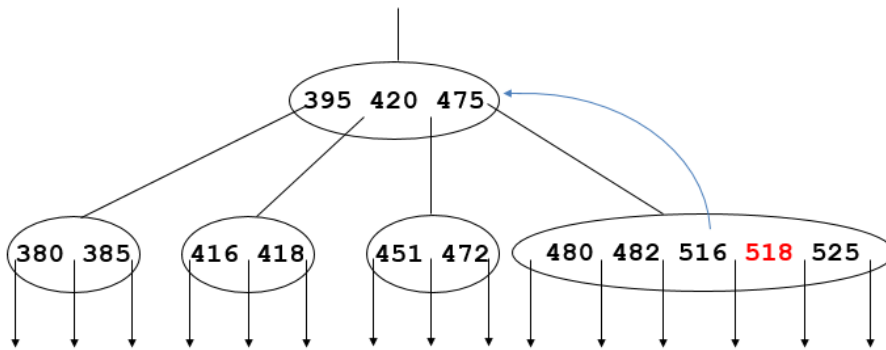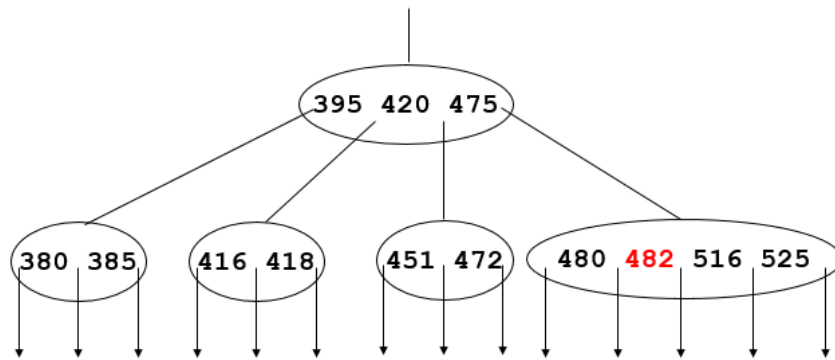## 1. Insert 30

2. Insert 20

3. Insert 8

4. Insert 40

5. Insert 60

6. Insert 70

7. Insert 3

3.

4.