RBT

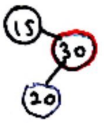
2) - Insert: 15

1. No root
2. See 15 as root, color it black

- Insert: 30

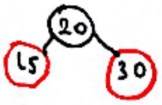
1. 30 > 15, go right
2. 30 as child of 15
3. Color red.

- Insert: 20



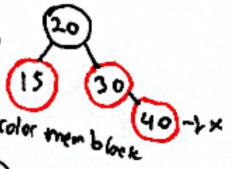
1. 20 > 15, go right
2. 20 < 30, left
3. as child of 30, color red
4. 2 consecutive red, rotate right left

5. Change/swap color between new child and parents

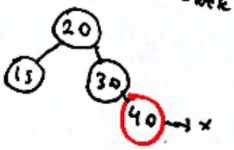


- Insert: 40

1. 40 > 20, 40 > 30, right child of 30 (red)

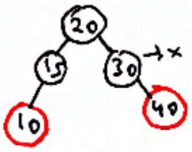


2. 2 consecutive red, as Parent and uncle is red, color them black
3. Color root black



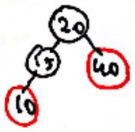
- Insert: 10

1. 10 < 20, 10 < 15, left child of 15 (red)

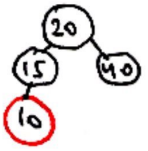


2. End.

- Delete: 30

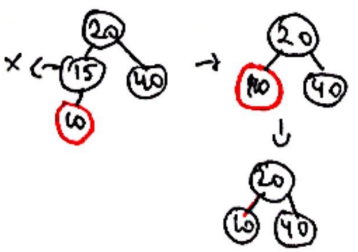


1. Search 30 (30 is right child of 20)
2. 30 = internal black node. As children red, pop 30, connect 20 with 40
3. Color 40 with black (recolor)



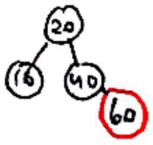
- Delete: 15

1. Search 15 (left child of 20)
2. 15 = internal black node with red children.
3. Pop 15, connect 10 with 20, color 10 as red



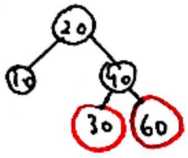
- Insert: 60

1. 60 > 20, 60 > 40 (as right children of 40)
2. Color 60 red



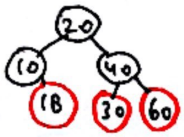
- Insert : 30

1. 30 > 20, 30 < 40 (left children of 40)
2. Color 30 red



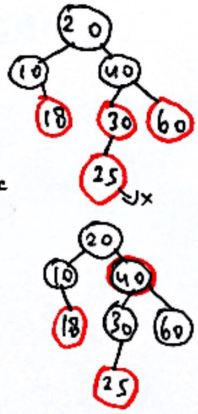
- Insert: 18

1. 18 < 20, 18 > 10 (right child of 10)
2. Color 18 red



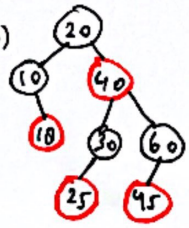
- Insert: 25

1. 25 > 20, 25 < 40, 25 < 30 (left child of 30)
2. Color 25 red
3. Parent x and uncle is red, color them black
4. If grand Parent black, recolor them red



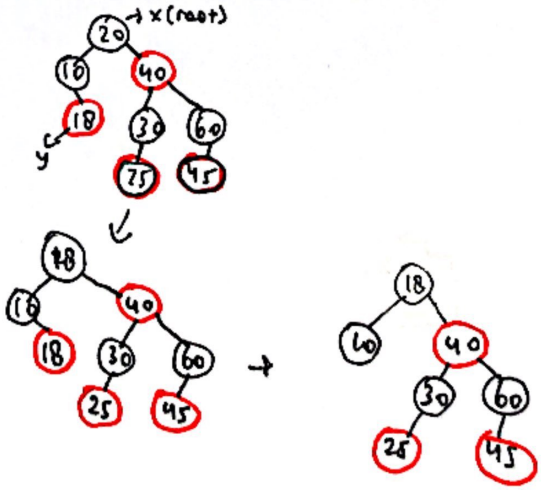
- Insert: 45

1. 45 > 20, 45 > 40, 45 < 60 (left child of 60)
2. Color 45 red



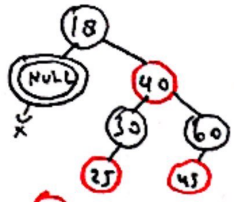
- Delete: 20

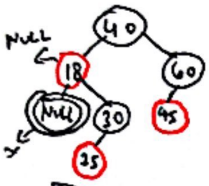
1. Search 20 (as root)
2. 20 : internal black node, search for Predecessor (18)
3. replace x with 18, Pop y(18)

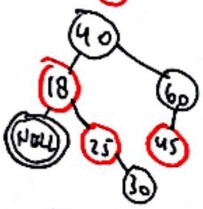


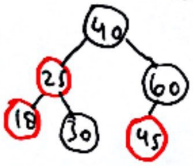
Delete: 10

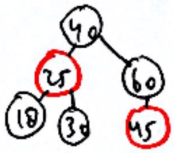
1. Search 10 (left child of 18)
2. Delete 10, recolor black (double black)
3. left rotate for x's parent
4. swap color 18 and 40
5. resolve double black
6. right rotate parent x
7. Double black (x) has black sibling
8. Sibling has red children
9. Left rotate
10. recolor 18 black





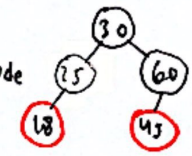






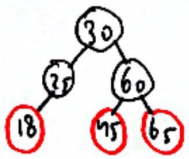
Delete: 40

1. 40: internal black node
2. Search predecessor (30)
3. replace node with 30, pop old 30's node



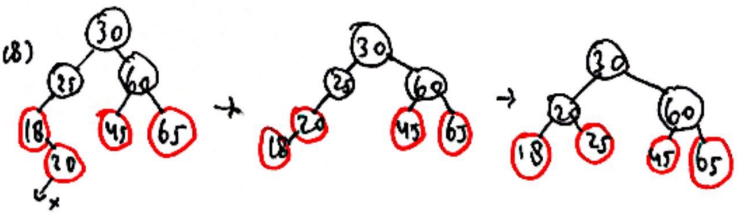
Insert: 65

1. 65 > 30, 65 > 60 (right child of 60)
2. Color 65 red



Insert: 20

1. 20 < 30, 20 < 25, 18 < 20 (right child of 18)
2. Color 20 red
3. left-right rotate
4. swap color 20 and 25



- Insert : 35

1. 35 > 30, 30 < 60, 30 < 45 (left child of 45)
2. color 35 red
3. 2 consecutive red / color of parent black
4. grandparent is not root, color red