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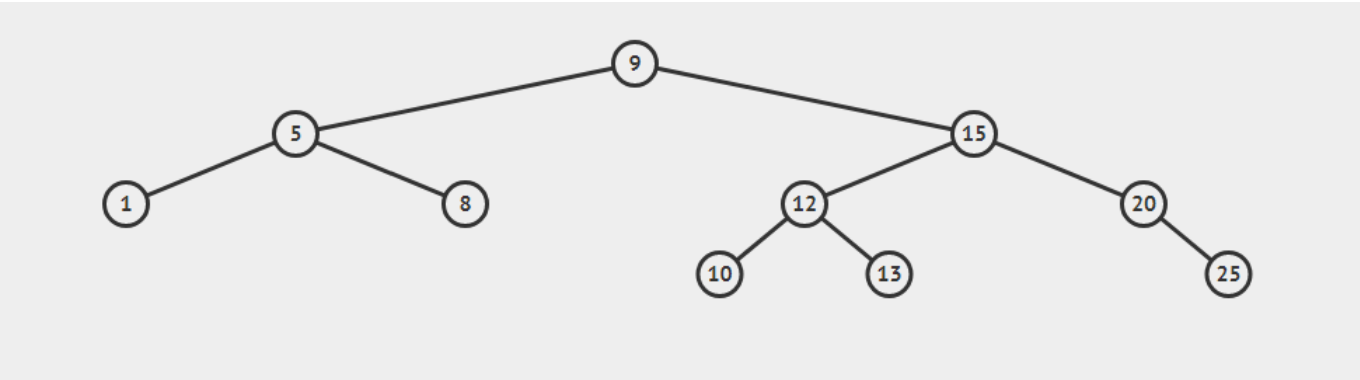
/**
* Title : Heaps and AVL Trees
* Author : Berk Yıldız
* ID: 21502040
* Section : 2
* Assignment : 3
* Description : Report for the questions 1, 2(b) and 3
*/
```

1.a)

- 9 inserted as root.
- 12 inserted as right child of 9, because 12 is greater than 9.
- 10 inserted and the tree balanced by double right-left rotation, new root is 10.
- 5 inserted as left child of 9.
- 1 inserted as left child of left subtree, then tree balanced by single right rotation.
- 8 inserted as left child of 9, tree balanced by double left-right rotation, new root is 9.
- 20 inserted as right child of right subtree, then tree balanced by single left rotation.
- 15 inserted as left child of 20.
- 13 inserted as left child of 15, then tree balanced by single right rotation.
- 25 inserted as right child of 20, then tree balanced by single left rotation.

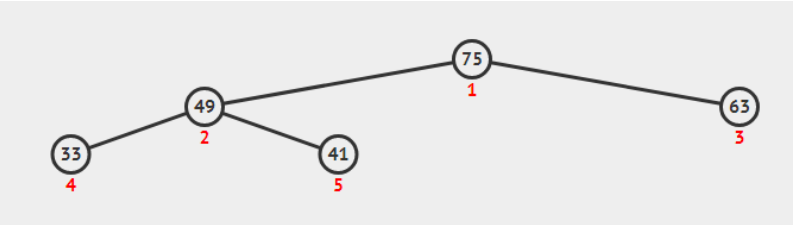


b)

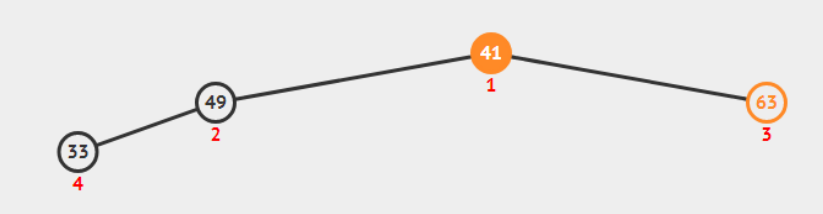
*Bolds and underlined are sorted region

Array Representation of Heap

75 49 63 33 41

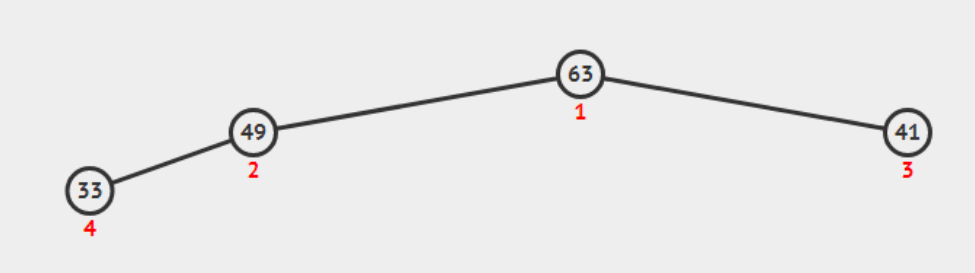


1- 41 49 63 33 **75**

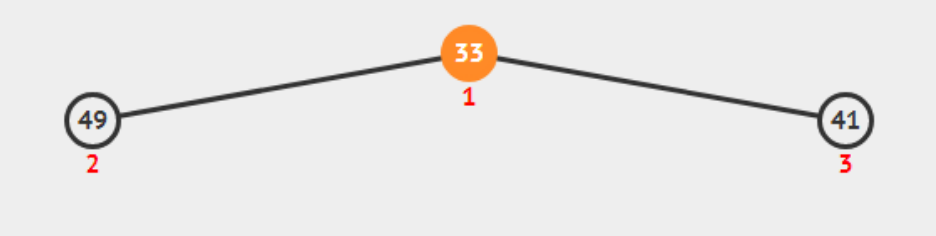


Rebuild

63 49 41 33 **75**

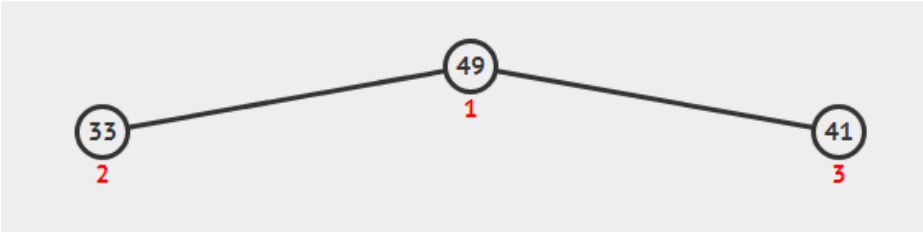


2- 33 49 41 **63 75**



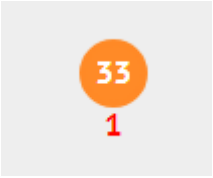
Rebuild

49 33 41 **63 75**

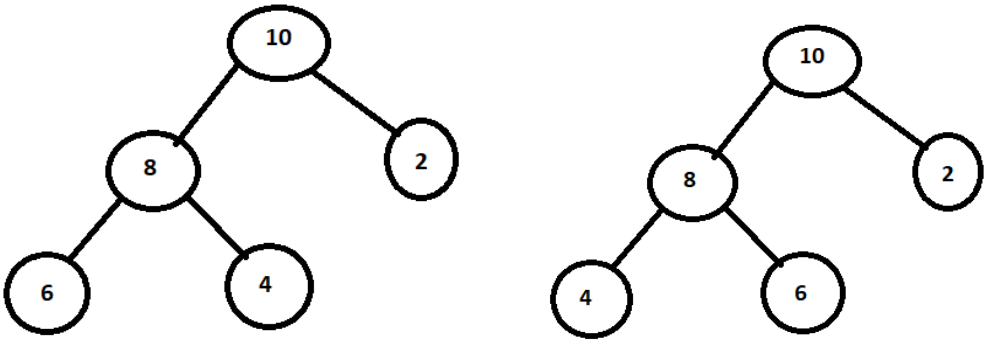


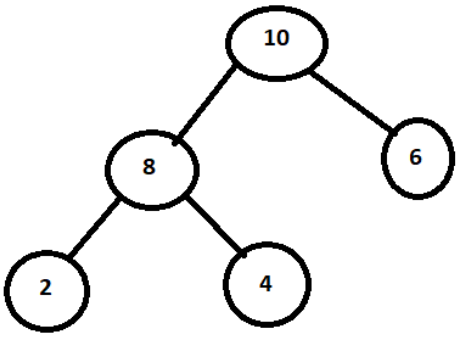
3- 41 33 **<u>49 63 75</u>**

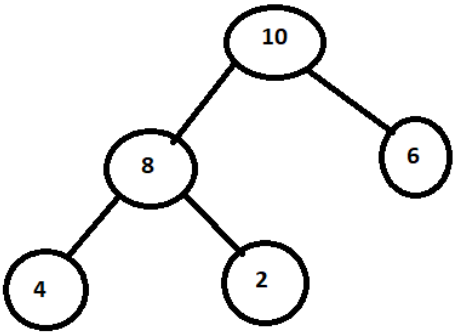
4- **<u>33 41 49 63 75</u>**

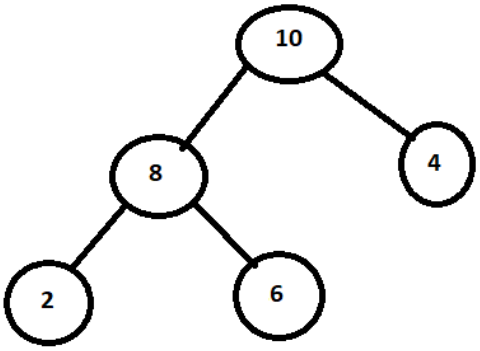


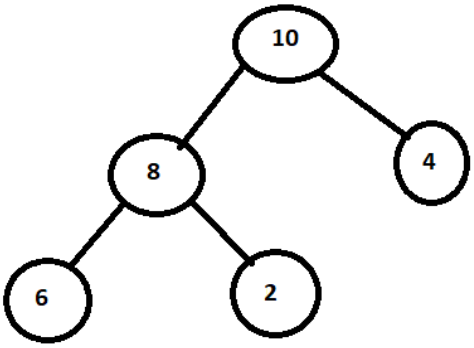
c)

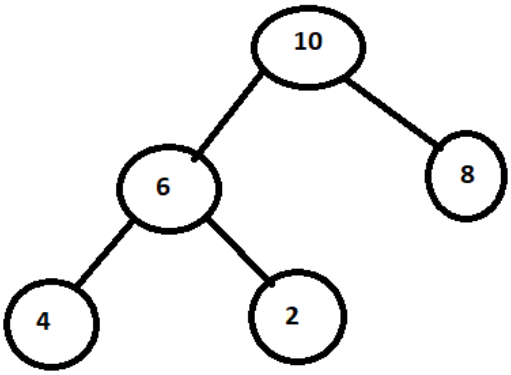


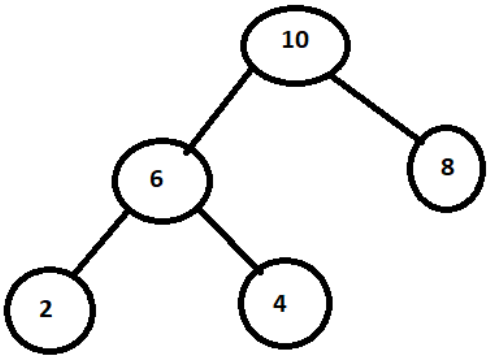

10
8
6
2
4


10
8
6
4
2


10
8
4
2
6


10
8
4
6
2


10
6
8
4
2


10
6
8
2
4

2.b)

```
berk.yildiz@dijkstra:~/21502040
17

          15

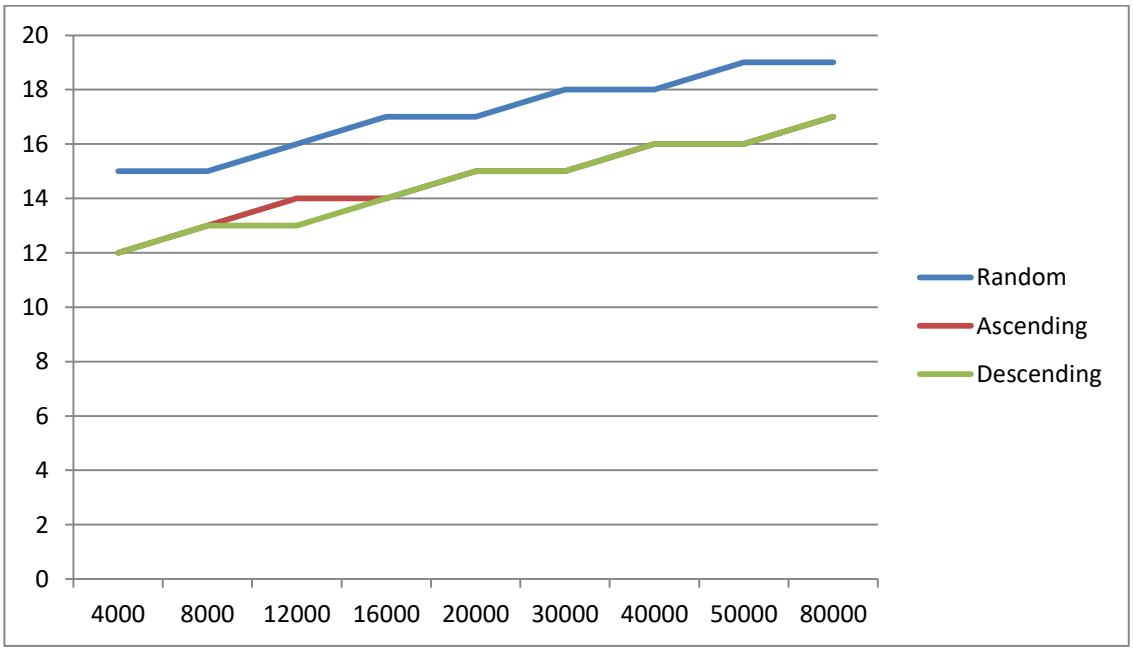
     12

          2


           Part b - Height analysis of AVL trees
-----------------------------------------------------------------
Array Size            Random          Ascending          Descending
-----------------------------------------------------------------
  4000                  15                12                 12
  8000                  15                13                 13
  12000                 16                14                 13
  16000                 17                14                 14
  20000                 17                15                 15
  30000                 18                15                 15
  40000                 18                16                 16
  50000                 19                16                 16
  80000                 19                17                 17
[berk.yildiz@dijkstra 21502040]$
```

3.

Height



Size

According to theorotical results in lecture slides there has to be minimum 376 nodes for height 12, 609 nodes for height 13, 986 nodes for height 14, 1596 nodes for height 15,

2583 nodes for height 16, 4180 nodes for height 17, 6764 nodes for height 18, 10945 nodes for height 19. Also the maximum node formula is the $2^{h+1} - 1$ where h is the height. According to empirical results, the results that I obtained are accurate because my collected data for the all specific sizes are in the interval of empirical minimum number of nodes and maximum number of nodes results.

The insertions and deletions which always damages the balance of the tree can be called as the worst case scenario for an AVL tree. Because for each time the tree gets unbalanced, rotations will be needed to make the tree balanced again. For example in a AVL tree, the insertions or deletions that causes if the only balanced nodes are leaves and all the other nodes(which are not leaf) have just left child or right child would be a worst case scenario for an AVL tree.