Data Structures and Algorithms
INFO 6205, Wed
Homework 6
Due: October 19, 2019

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Put all your java, compiled class files and documentation files into a zip file named Homework6.zip and submit it via the drop box on the blackboard before the END of due date. Put your name on all .java files. There will be a short quiz on this homework.

1. What is the Balanced Tree, Complete Tree and Non-Complete Tree?

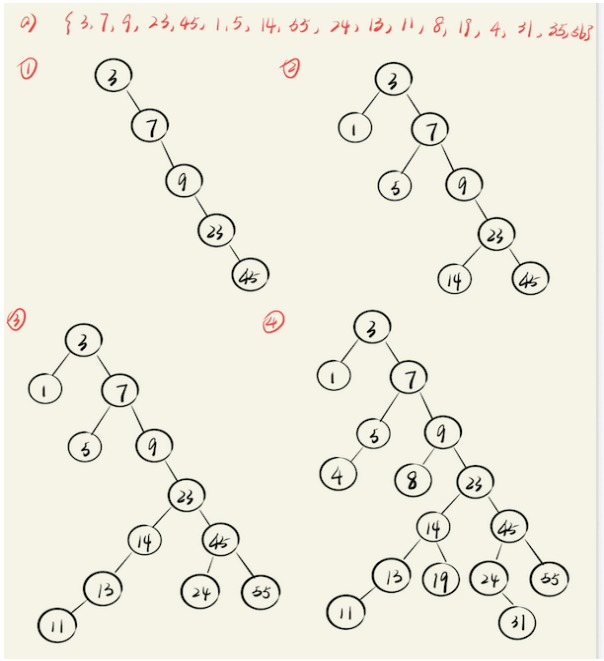
A balanced tree is a tree where every leaf is "not more than a certain distance" away from the root than any other leaf.

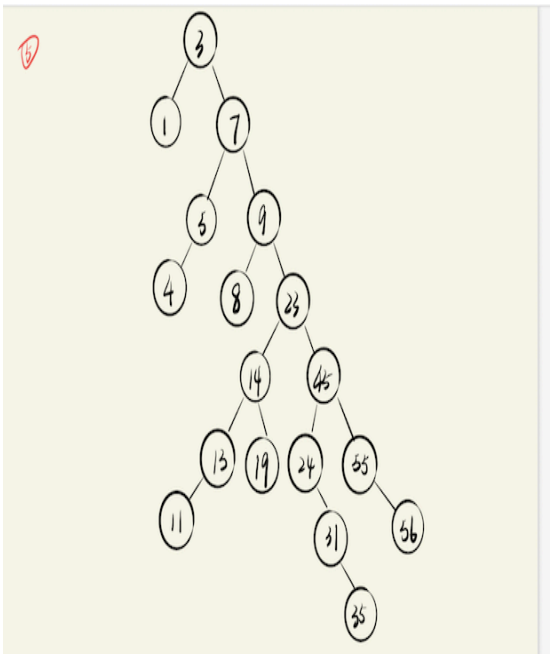
A complete tree is a tree in which every level, except possibly the last, is completely filled, and all nodes are as far left as possible.

Non-complete tree is tree in which every level is not completely filled and all nodes are not as far left as possible.

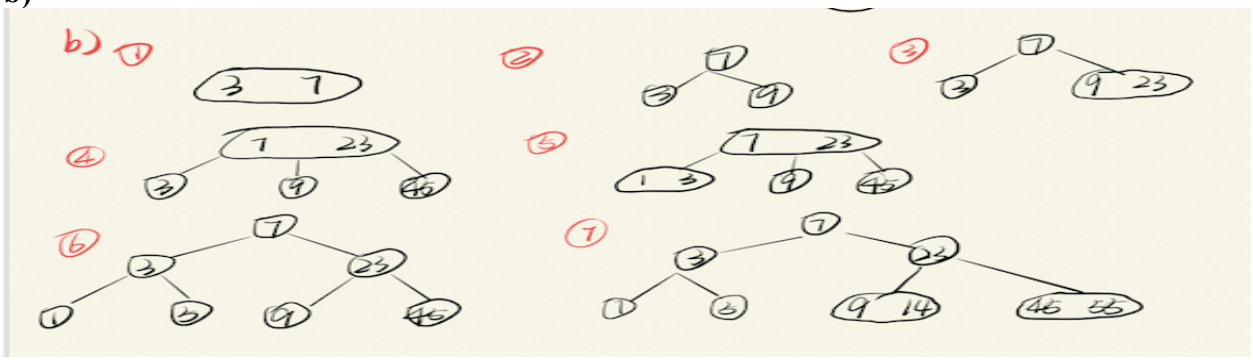
2. Consider following data: {3,7,9,23,45,1,5,14,55,24,13,11,8,19,4,31,35,56}
   a) Construct Binary Tree
   b) Construct 2-3 Tree
   c) Construct 2-3-4 Tree
   d) Construct Binary Heap Tree
   e) What is Time complexity of each case, Why would you use one versus the other?
   f) Insert 17, 22, 32, 6, 33 in (b)
   g) Delete 13 in (a) and (b)
   h) What is the Height of (a), (b), (c)?
   i) Write Java Search and Insert code for (a) and (b)
   j) Write Java code for DeleteMin() and DeleteMax Algorithms for (a), provide example

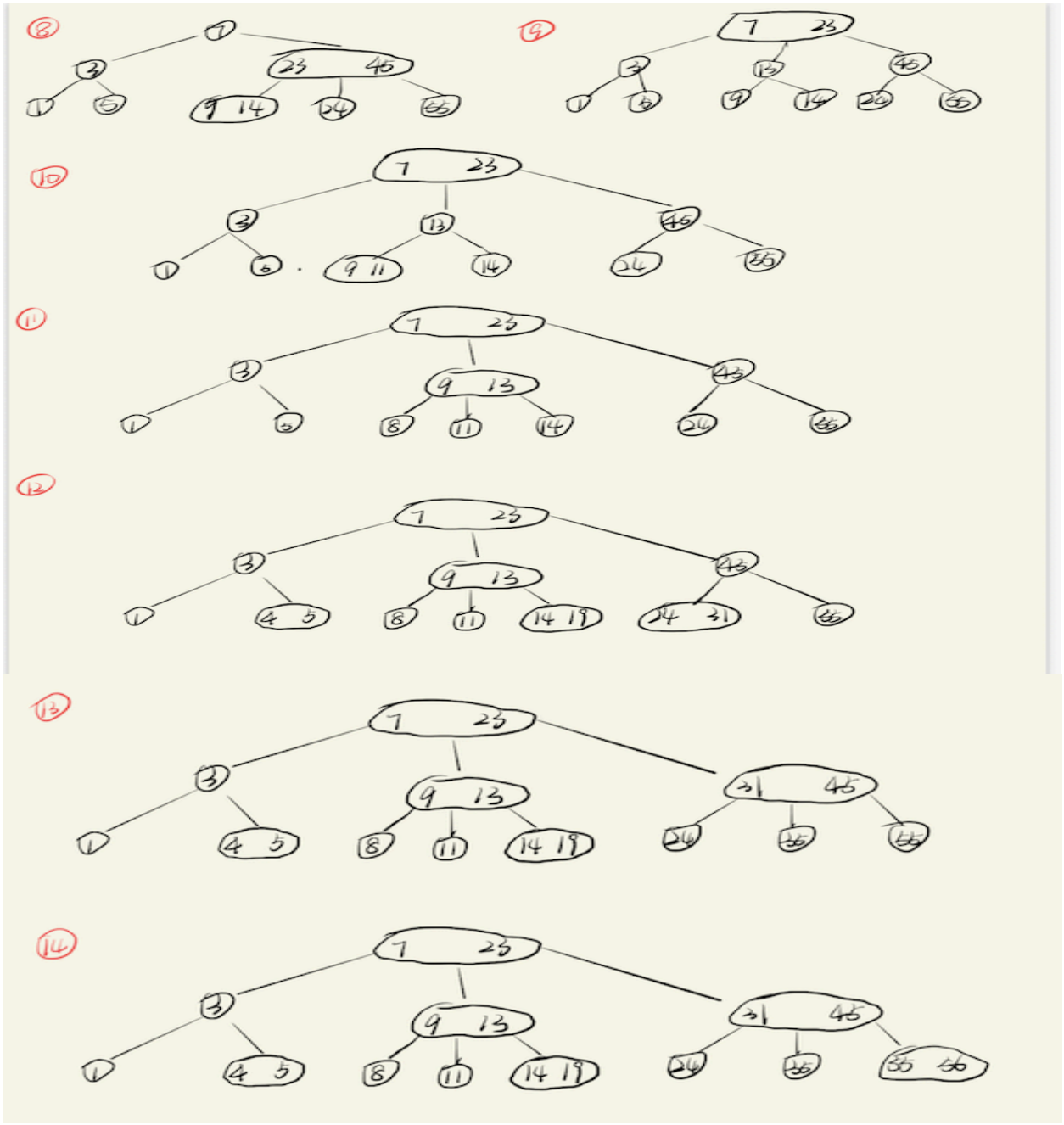
a)





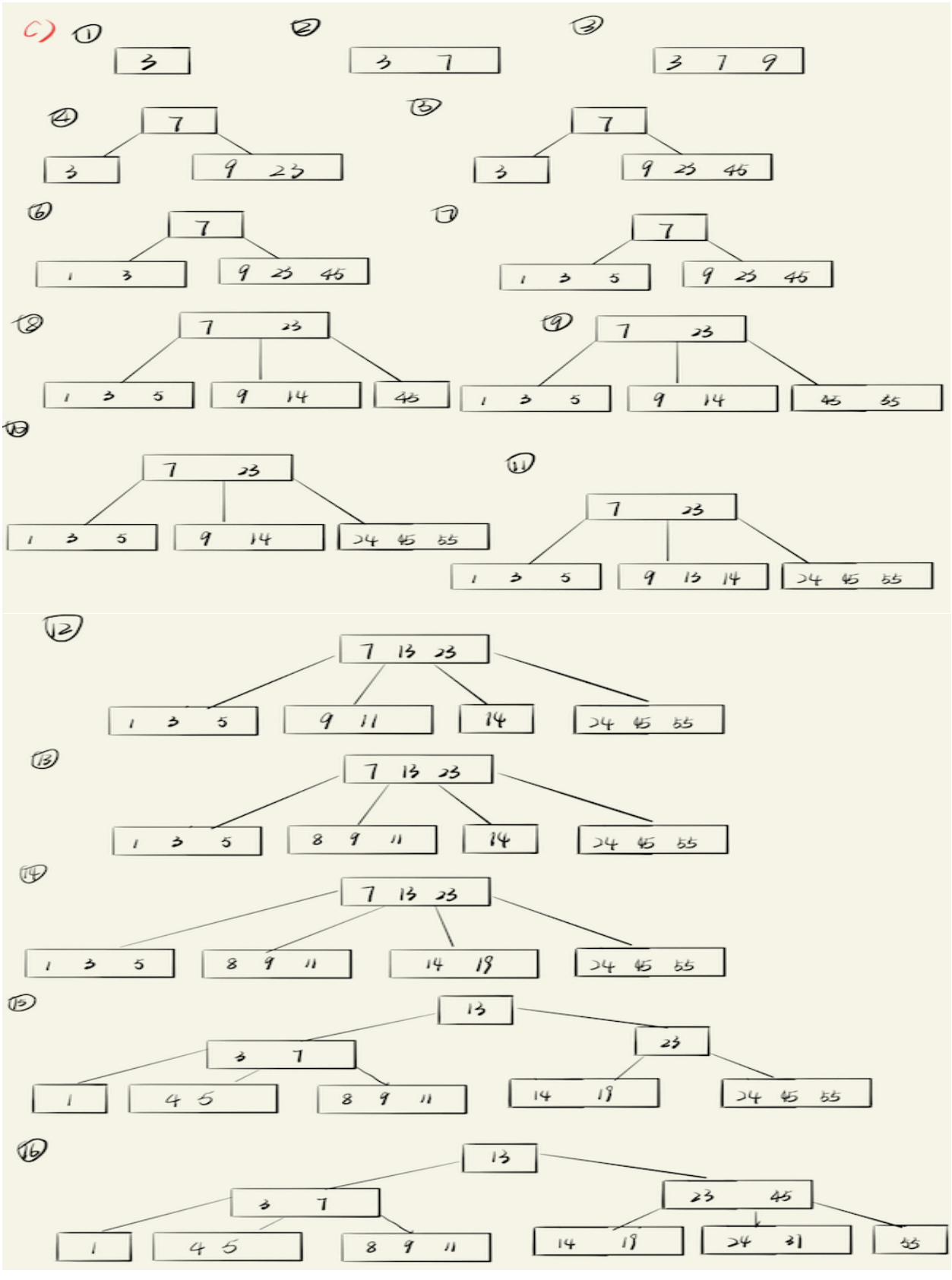
b)





c)

c)


1
3
2
3 7
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3 7 9
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9 23
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9 23 45
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1 3
9 23 45
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9 23 45
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9 14
45 55
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1 3 5
9 14
24 45 55
11
7 23
1 3 5
9 13 14
24 45 55
12
7 13 23
1 3 5
9 11
14
24 45 55
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7 13 23
1 3 5
8 9 11
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24 45 55
14
7 13 23
1 3 5
8 9 11
14 18
24 45 55
15
13
3 7
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4 5
8 9 11
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3 7
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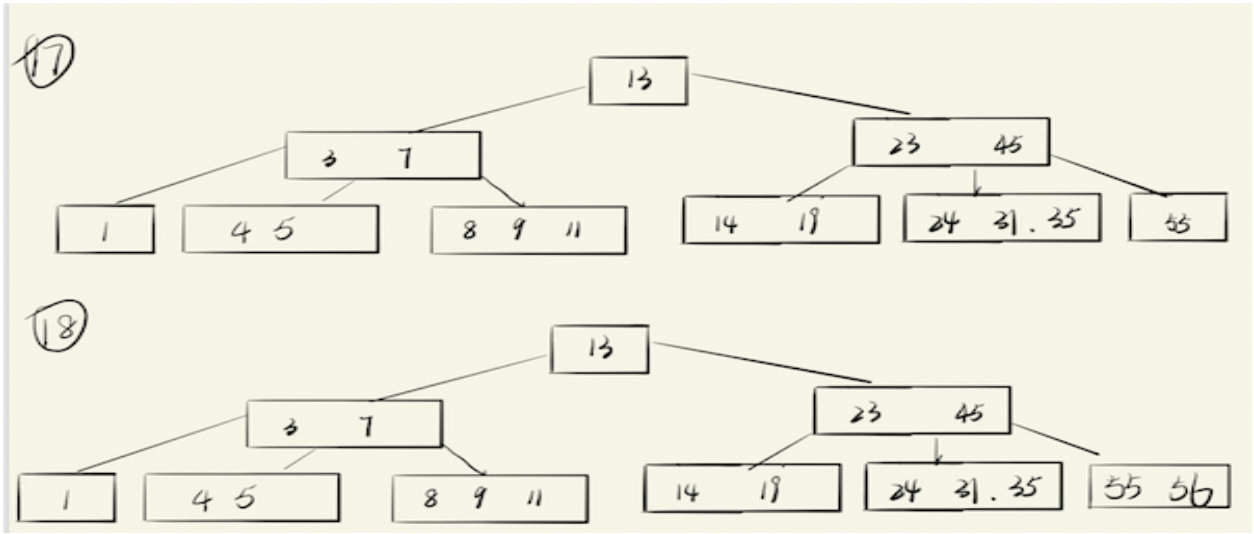
4 5
8 9 11
14 18
24 31
55


17
13
3 7
23 45
1
4 5
8 9 11
14 19
24 31 35
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18
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3 7
23 45
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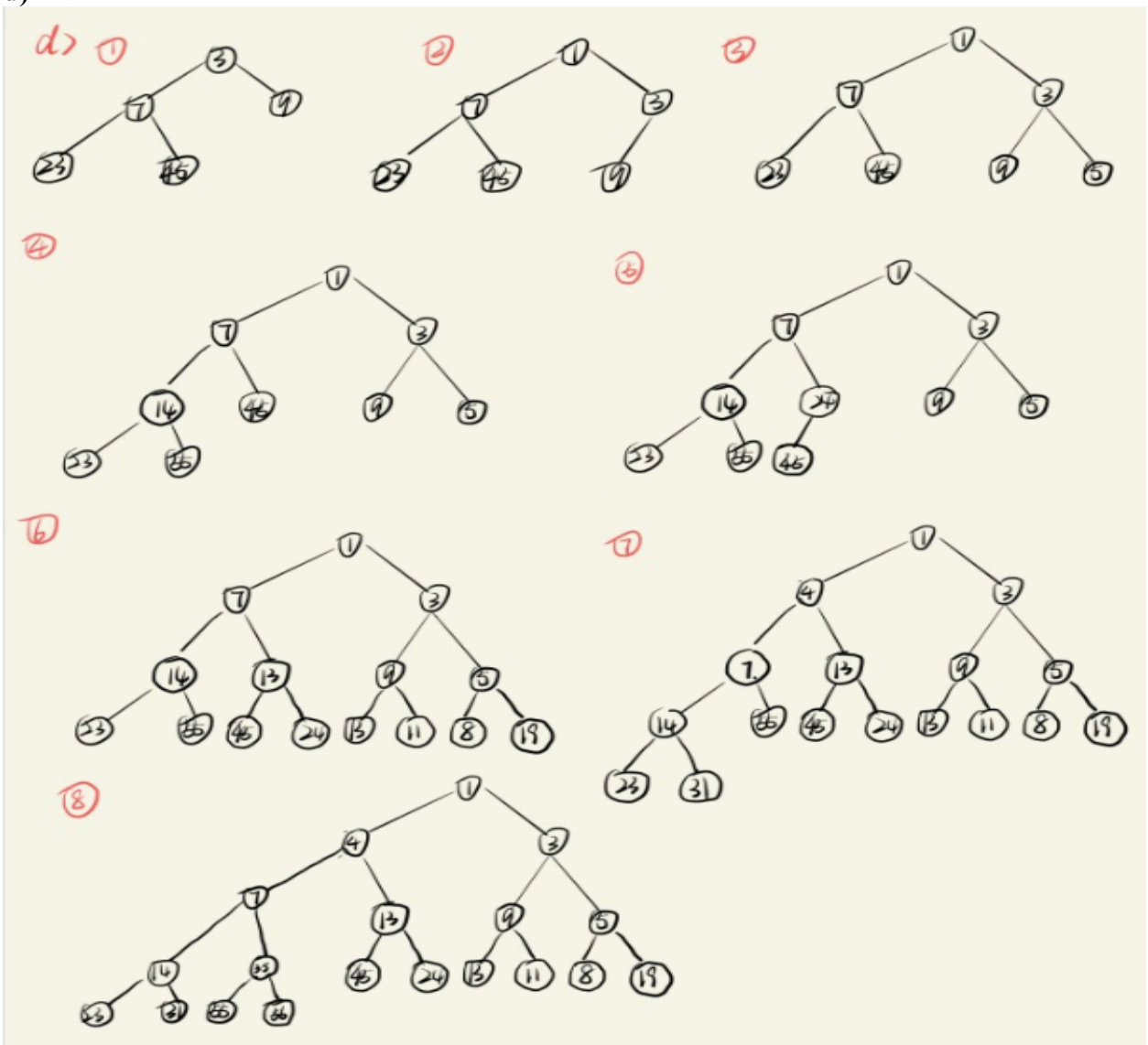
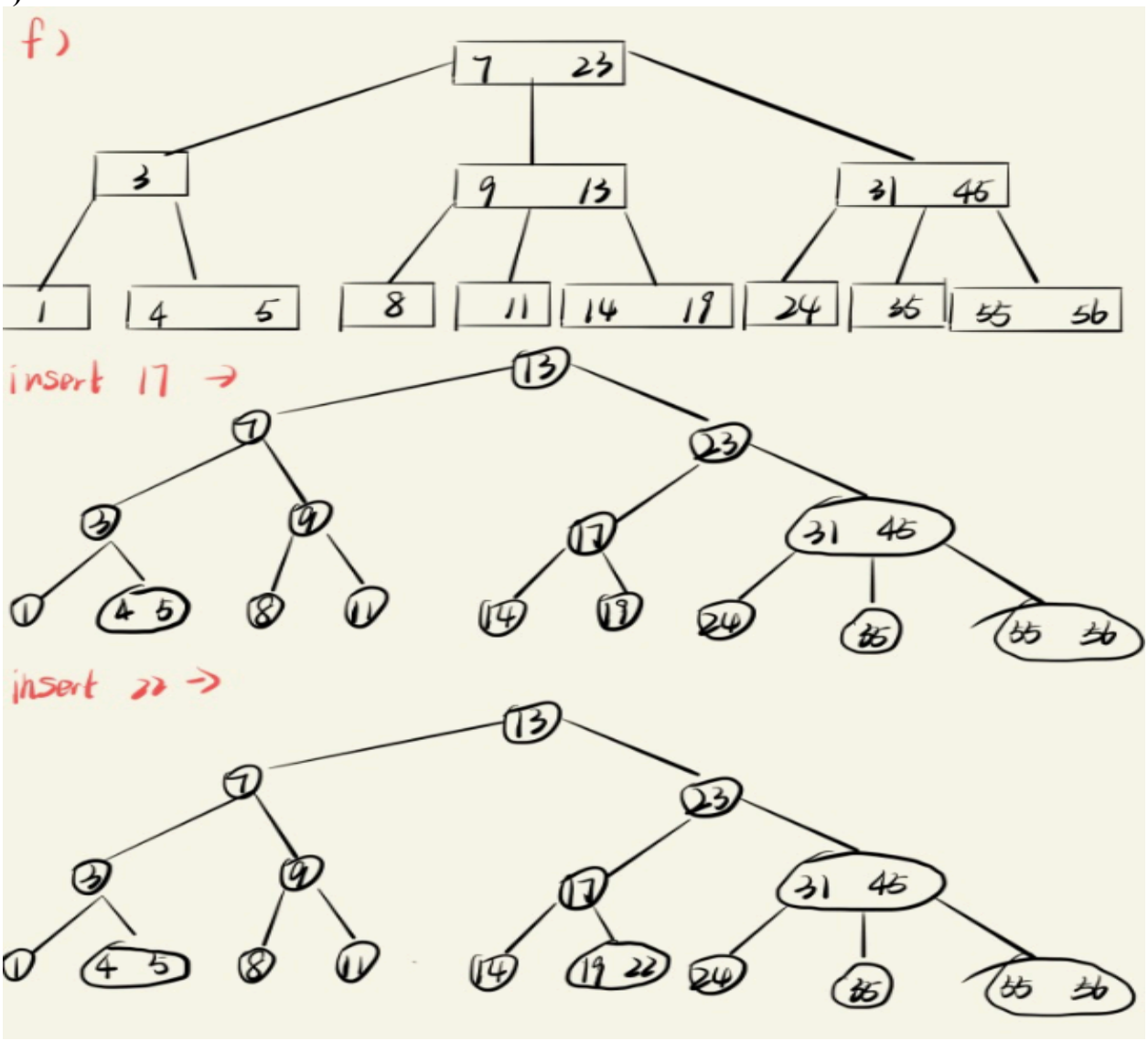
4 5
8 9 11
14 19
24 31 35
55 56

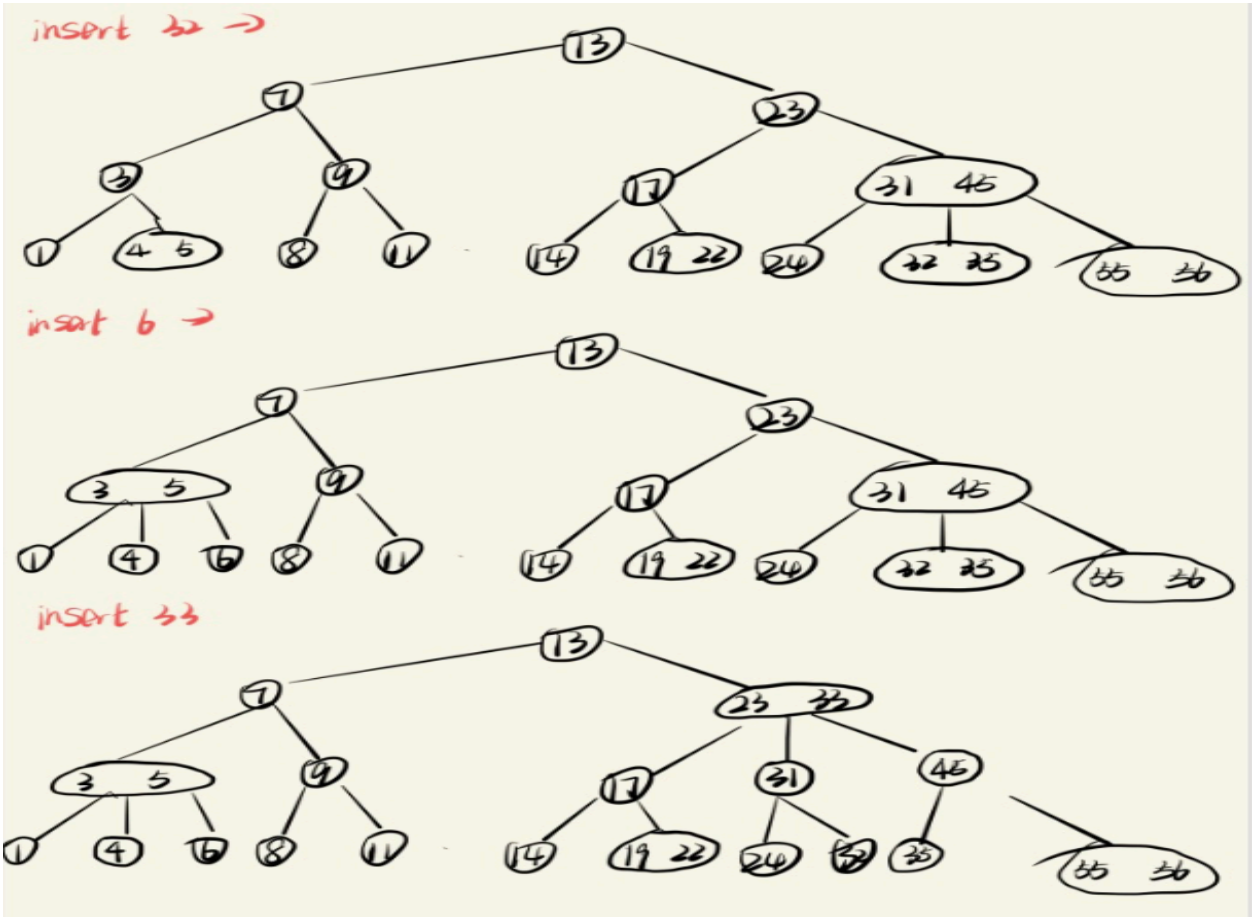
d)


d)
1
2
3
4
5
6
7
8

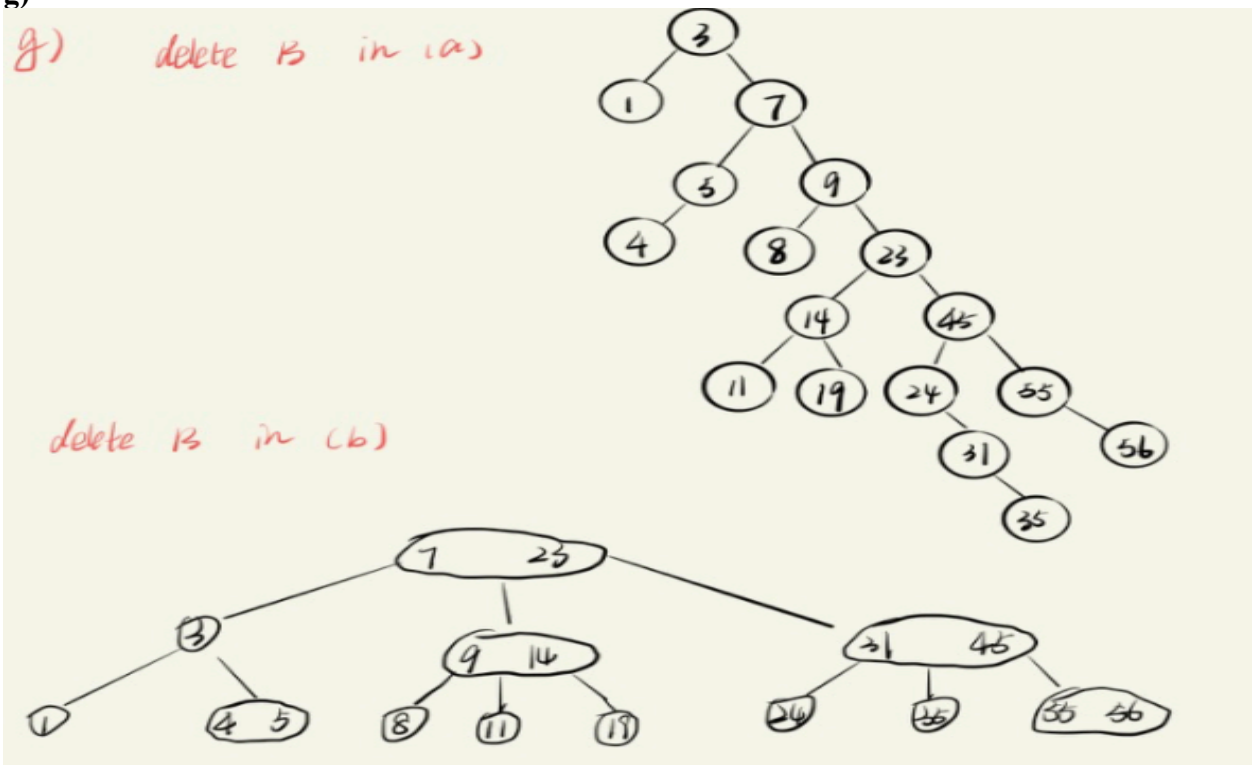
e)
Time complexity of Binary Tree in worst case is O(n), if it is balanced, the time complexity in average case is O (log n) when it is inserted, search, delete.
Time complexity of 2-3 Tree and 2-3-4 Tree in worst case is O(log n), the time complexity in average case is O(log n) when it is inserted, search, delete.
Time complexity of Binary Heap Tree in worst case is O(log n), the time complexity in average case is O(1) when it is inserted.
Search: worst case and average case are both O(n).
delete: worst case and average case are both O(log n).

2-3 Tree and 2-3-4 tree is stable and suitable for the large amount of data because the time complexity in worst case or in average case are always O(log n) when insertion, delete, search.
Binary Tree is unstable and lowest.
Binary Heap Tree is fastest when we insert data, it is easy to find max data or min value.
f)



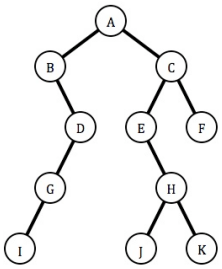


g)

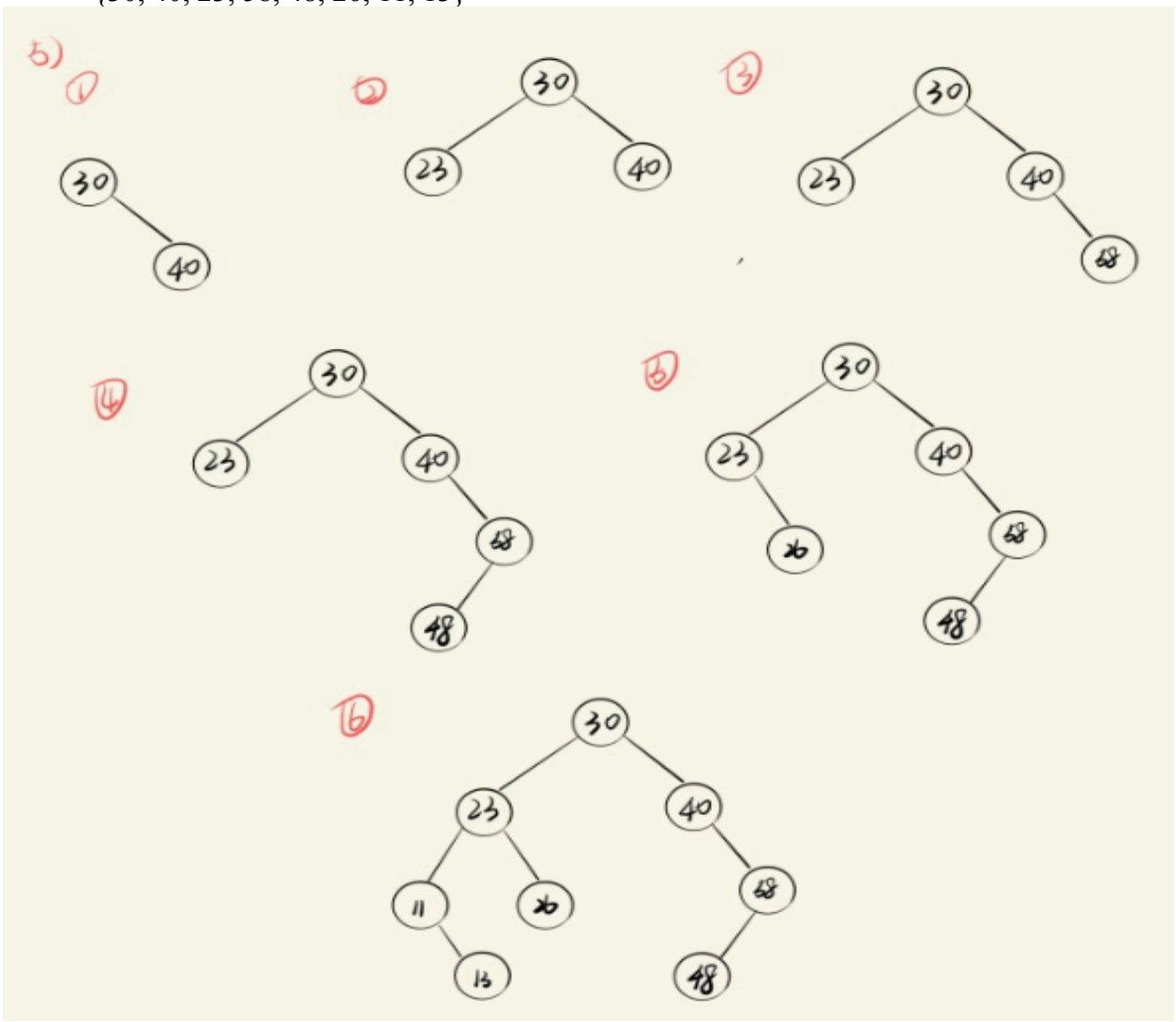


h) The Height of (a):7
The Height of (b):2
The Height of (c):2
i) See the code in H6_2_i.java
j) See the code in H6_2_j.java

4. Consider the following Binary tree, write Java code to find **minimum** element in binary search tree. You may write either a recursive or iterative implementation.



5. Insert the following items into an empty binary search tree in order:
{30, 40, 23, 58, 48, 26, 11, 13}



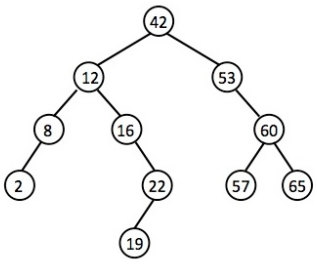
6. What is the maximum height of a binary search tree in problem-5? Why?
What is the time complexity of the Tree you built in problem-5? Why?

N is the number of elements of binary search tree.

The maximum height of a binary search tree is N-1, the maximum height of a binary search tree in problem 5 is 7. Because if the inserted element is in an ascending order, the elements will be only inserted in the right.

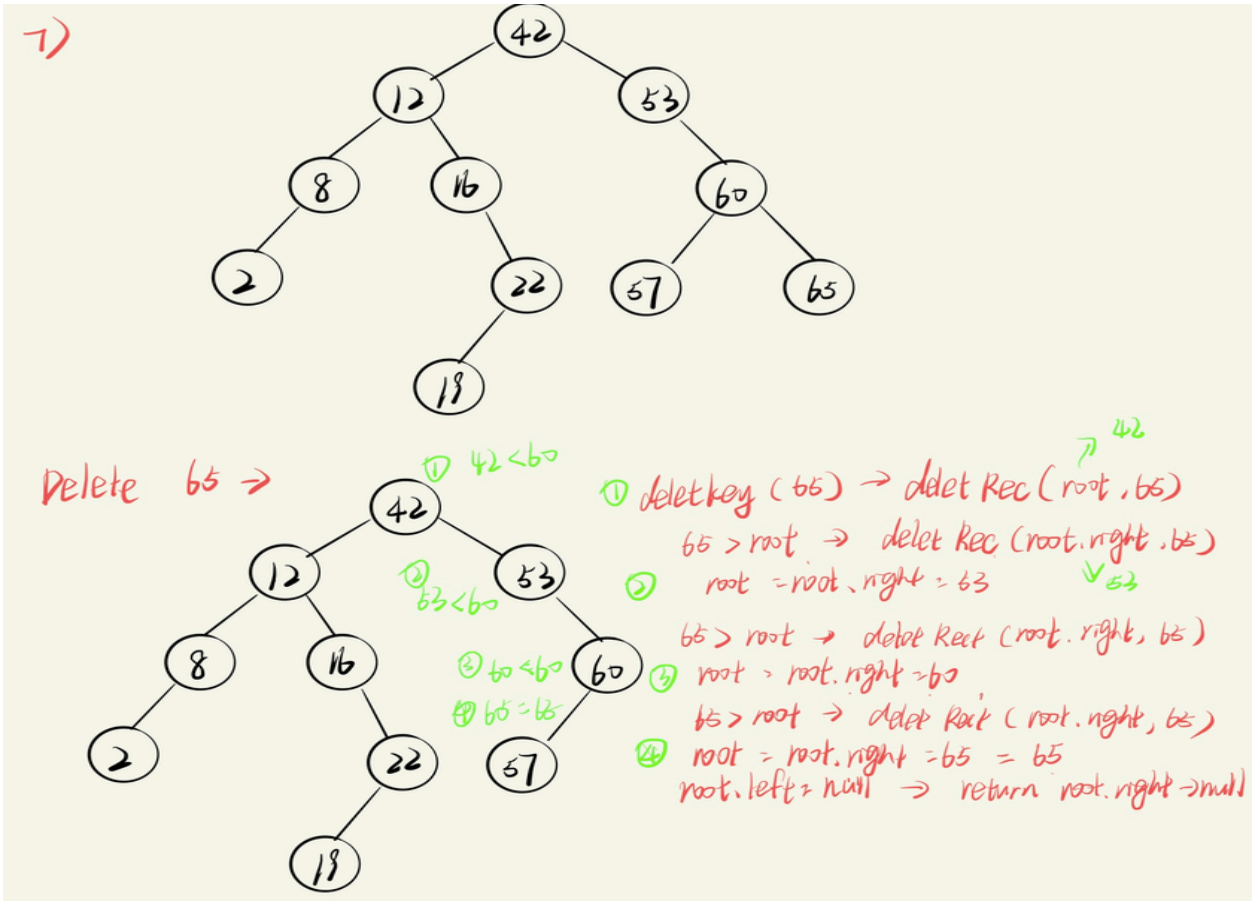
Time complexity of Binary Tree in worst case is O(n), if it is balanced, the time complexity in average case is O (log n) when it is inserted, search, delete. Because the tree in problem-5 is not balanced, the time complexity of the Tree in problem-5 is O(n), n=8.

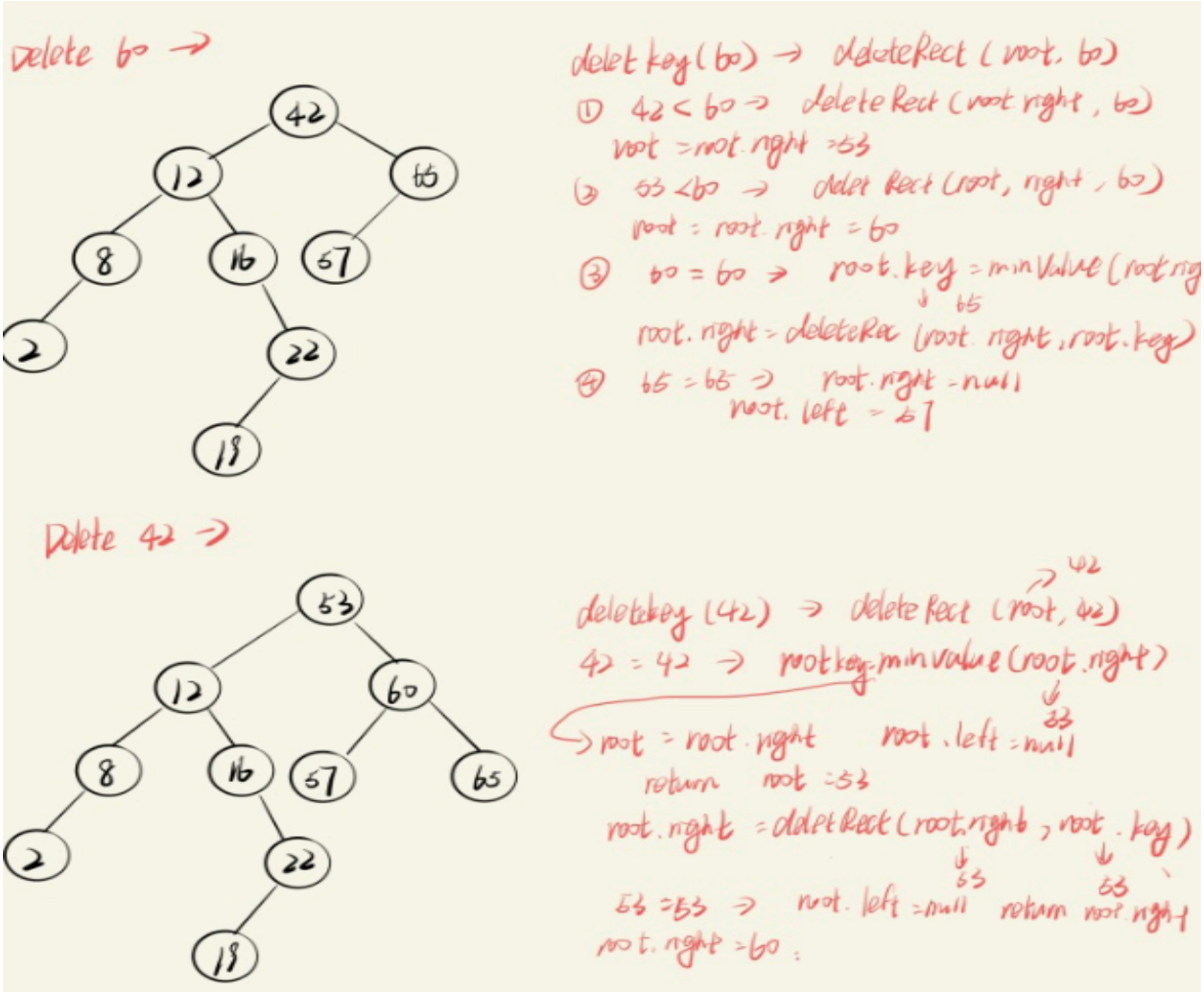
7. Consider the following binary tree:



Use BST functions deleteKey, deleteRec, and minValue discussed in class: Show step-by-step code logic to delete the following nodes and redraw the binary tree for each deletion:

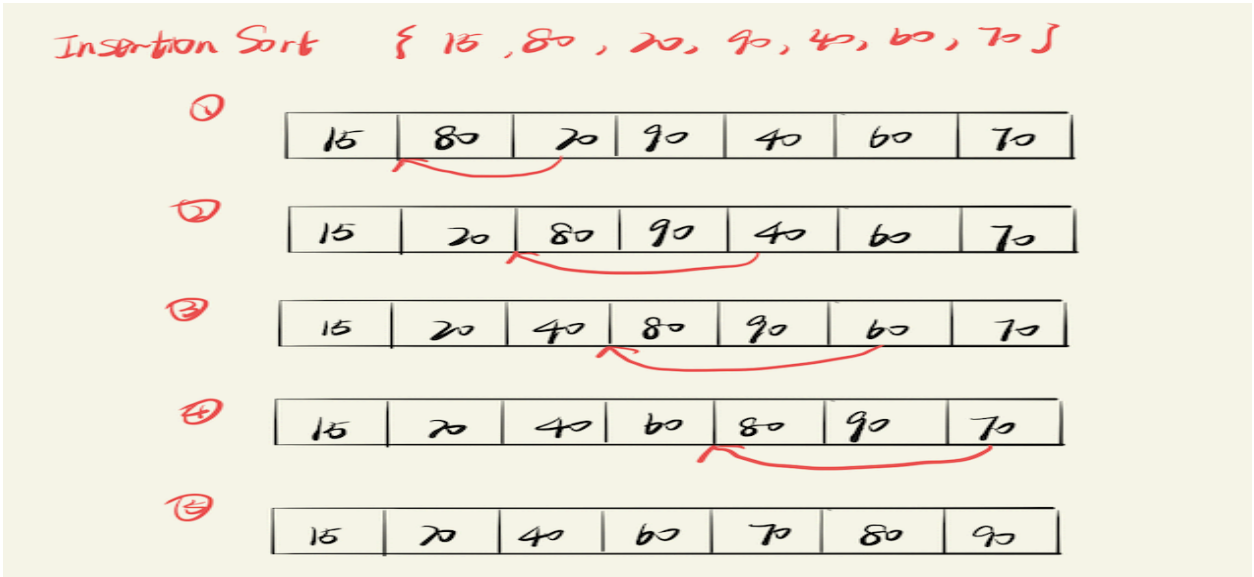
Delete 65 Delete 60 Delete 42





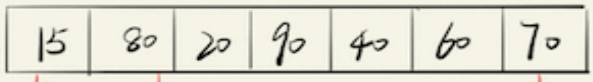
8. Consider arr[] = {15, 80, 20, 90, 40, 60, 70}. Walk through InsertionSort, SelectionSort, TimSort, and QuickSort algorithms, show step by step how the sort works.

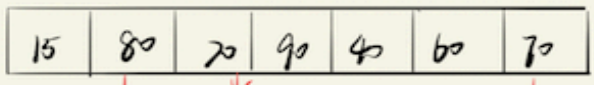
InsertionSort:



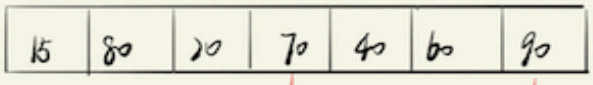
QuickSort:

Quick Sort : { 15, 80, 20, 90, 40, 60, 70 }

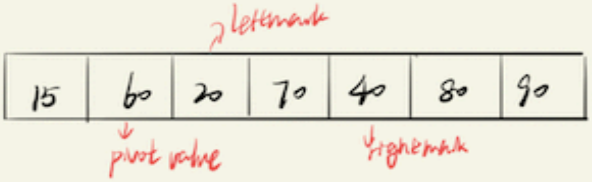
① 

② 

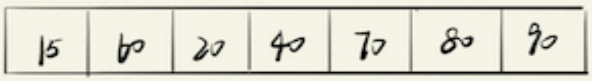
15<80 15<70 15<90
15<40 15<60 15<70
leftmark = rightmark stop
then quicksort(1,6)

③ 

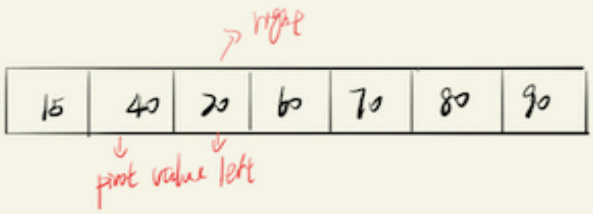
80>20 80<90 stop
80>70 stop exchange 70 and 90

④ 

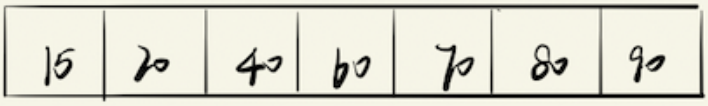
40<80 60<80 leftmark>rightmark stop
exchange 80 and 60
quicksort(1,4)

⑤ 

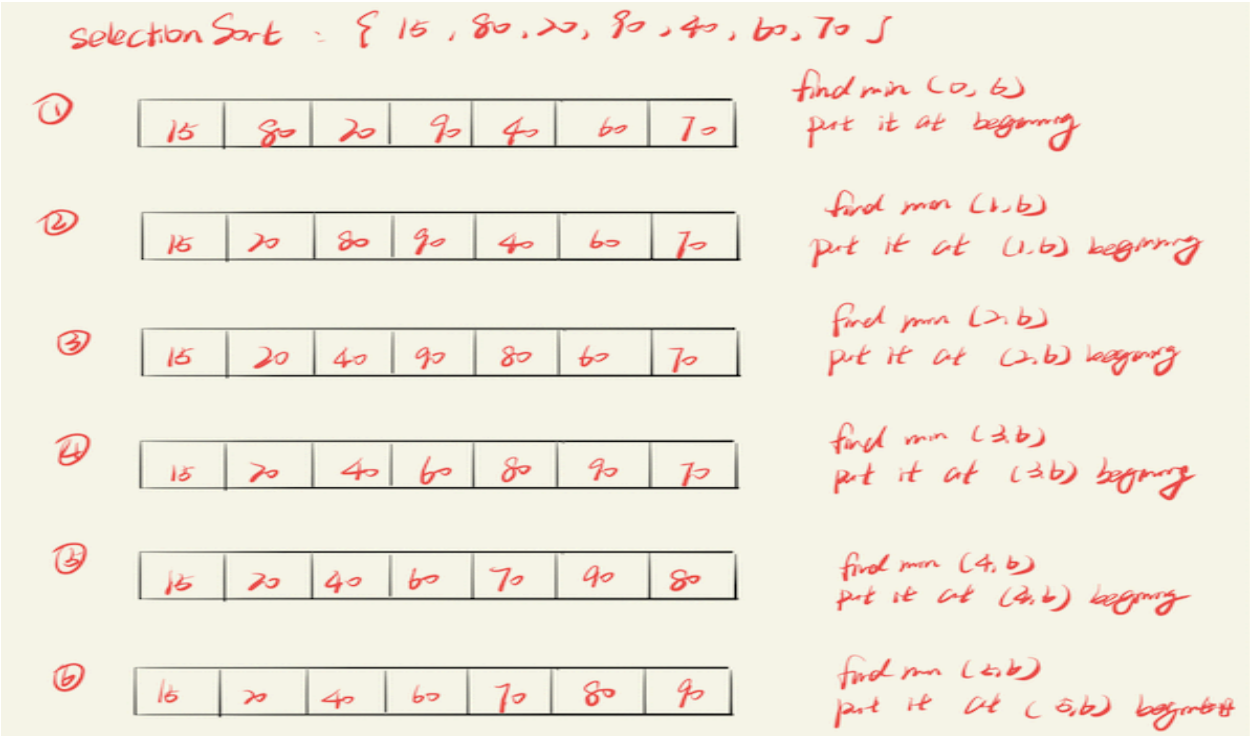
60>20 60<70 stop
60<40 stop exchange 40 and 70

⑥ 

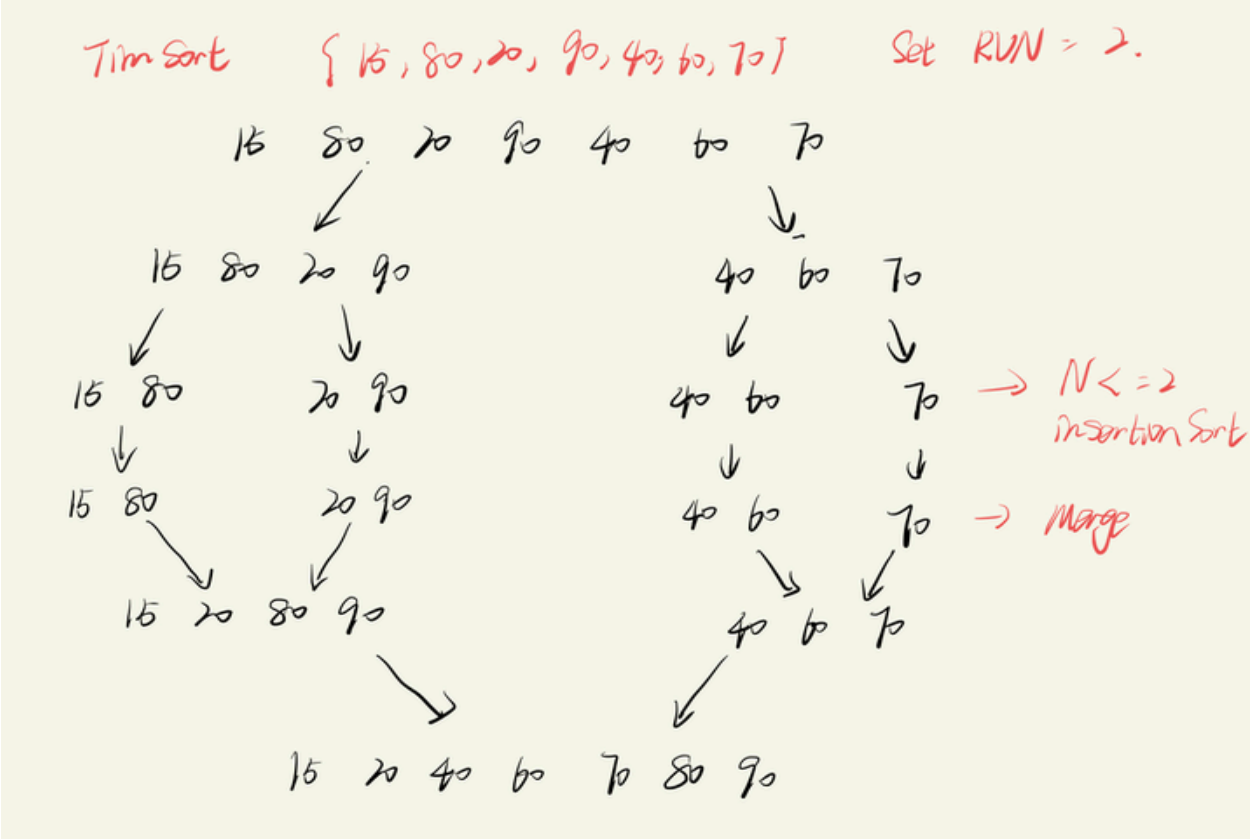
exchange 60 and 40
quicksort(1,2)
exchange 20 and 40

⑦ 

SelectionSort:



Timsort:



9. Consider attached image Boston.jpg. Write a program to sort the image Pixels by "brightness". You program for four sorting algorithms: InsertionSort, SelectionSort, TimSort, and QuickSort, MergeSort. You need to sort the Pixel array size of the image in Ascending order and compare and show the runtime time complexity of each Sorting algorithm.

Notes:

You may NOT use any Java library function for sorting. You should use ONLY the Sorting Java code I provided in class. The Pixel sorting should start from (0,0) to (high,high) for Brightness. For each Pixel, you need to convert RGB color to appropriate intensity. Use intensity formula: I = 0.2989R + 0.5870G + 0.1140B. If the current pixel Intensity is larger than the next pixel intensity, you need to swap, going in descending order.

	InsertionSort	**SelectionSort**	**TimSort**	**QuickSort**	**MergeSort**
Worst case	**O(n^2)**	**O(n^2)**	**O(nlog n)**	**O(n^2)**	**O(nlog n)**
Best case	**O(n)**	**O(n^2)**	**O(n)**	**O(nlog n)**	**O(nlog n)**
Average case	**O(n^2)**	**O(n^2)**	**O(nlog n)**	**O(nlog n)**	**O(nlog n)**