GATE

CRASH COURSE

Data Science & AI

Subject

Data Structure & Algorithms
BST and Binary Heap
Lecture No. - 05

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Last Class

Quick Recap

1. Trees Terminology
2. Types Of Binary Trees
3. Tree Traversals
4. Formulae of Binary Trees

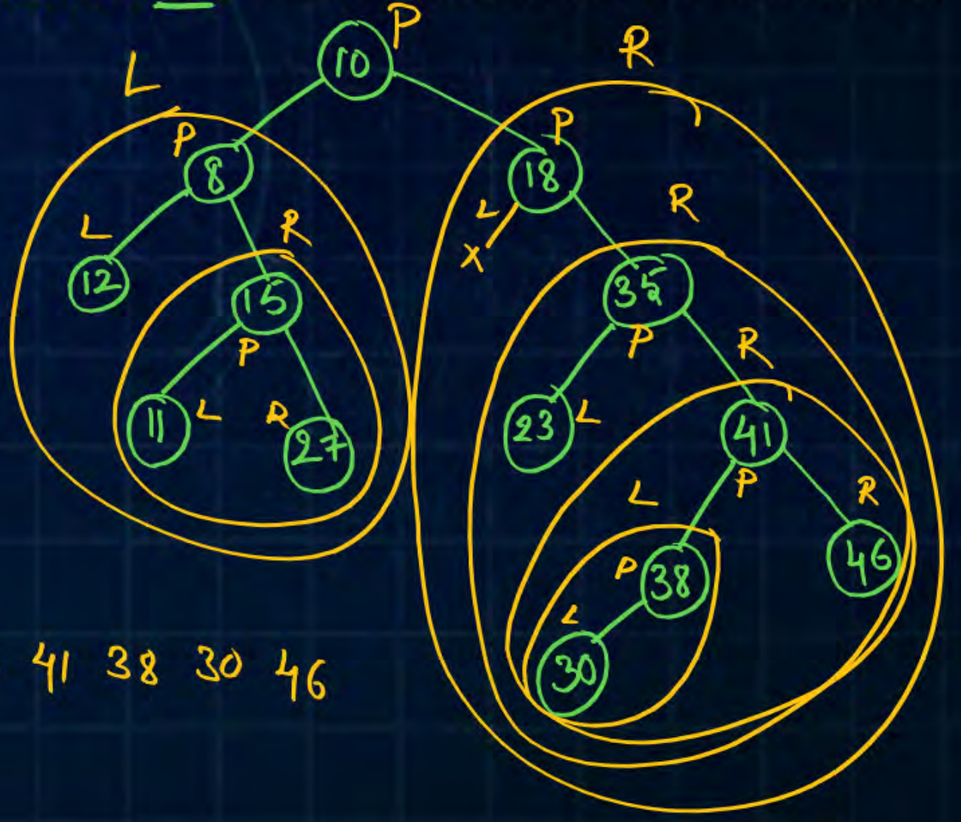
Topics to be covered

1. Homework Problem Solution
2. BST – Insertion, Construction
3. BST - Deletion
4. Binary Heap – Insertion, Deletion
5. Examples

Homework Problem

#Q. Consider the In-order traversal of a binary tree is 12 8 11 15 27 10 18 23 35 30 38 41 46 and Post order traversal is 12 11 27 15 8 23 30 38 46 41 35 18 10. The Pre Order Traversal is _____

a. 10 8 12 15 11 27 18 35 41 23 38 30 46
b. 10 8 12 15 11 27 18 35 23 41 30 38 46
c. 10 8 12 15 11 18 27 35 23 41 38 30 46
d. 10 8 12 15 11 27 18 35 23 41 38 30 46



Pre order Traversal (PLR) : 10 8 12 15 11 27 18 35 23 41 38 30 46

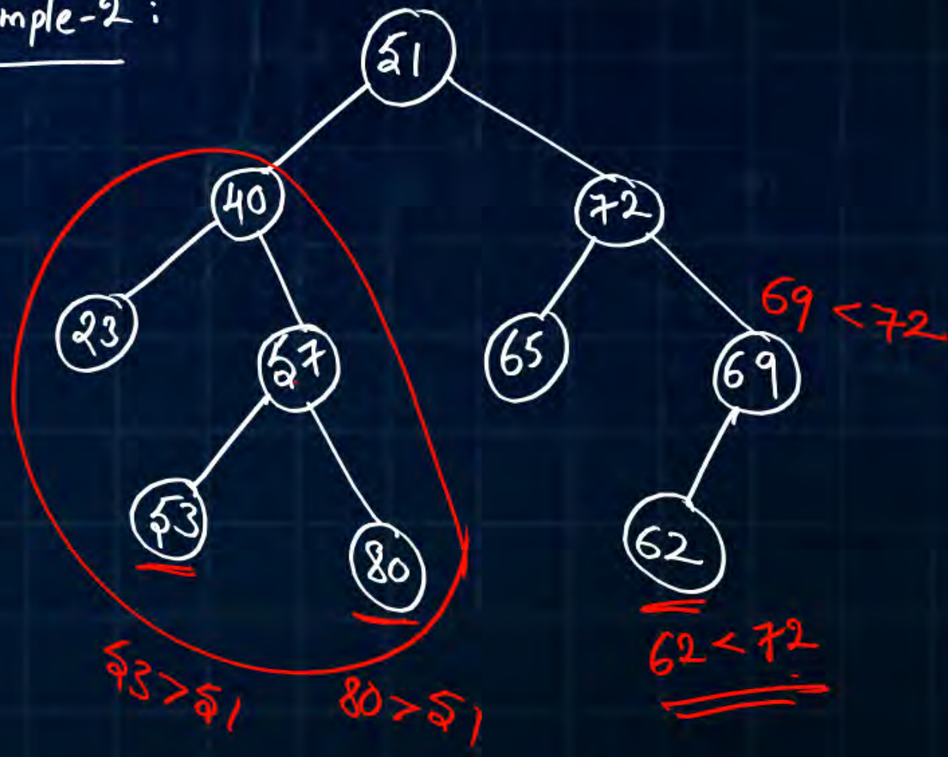
Binary Search Tree

- A Binary Tree, in which **Left Subtree < Parent < Right Subtree** At Each level, is known as BST

Example : 1

Binary Search Tree

Example-2 :

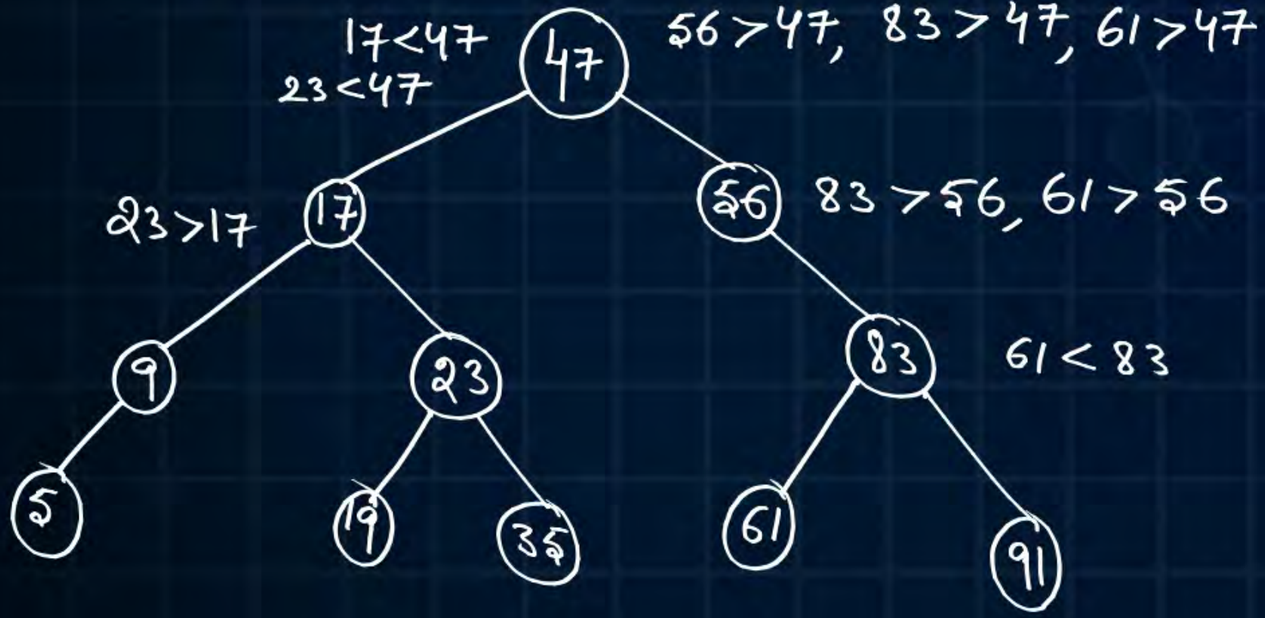


Not a Binary Search Tree

Binary Search Tree

#Q. Construct a BST by Inserting elements, in the order : 47, 56, 83, 17, 61, 23, 19, 9, 5, 91, 35.

The Resultant BST is _____



Resultant BST

= 47, 17, 56, 9, 23, 83, 5, 19, 35, 61, 91

Binary Search Tree

Insertion into BST :

Consider a BST:

Insert 5 : Compare 5,10 5<10

1 Comparision

Time complexity = O(1)

Best-case

Insert 25 : Compare 25,10 25>10

Compare 25,20 25>20

Compare 25,30 25<30

3 Comparisions $= \lceil \log_2^2 \rceil$

Time complexity $\Rightarrow O(\log_2 n)$

Average-case

Insert 55 : Compare: (10,55)

(20,55)

(30,55)

(40,55)

(50,55)

5 Comparisions.

Time complexity = O(n)

Worst-case

Binary Search Tree

Deletion of Element from BST

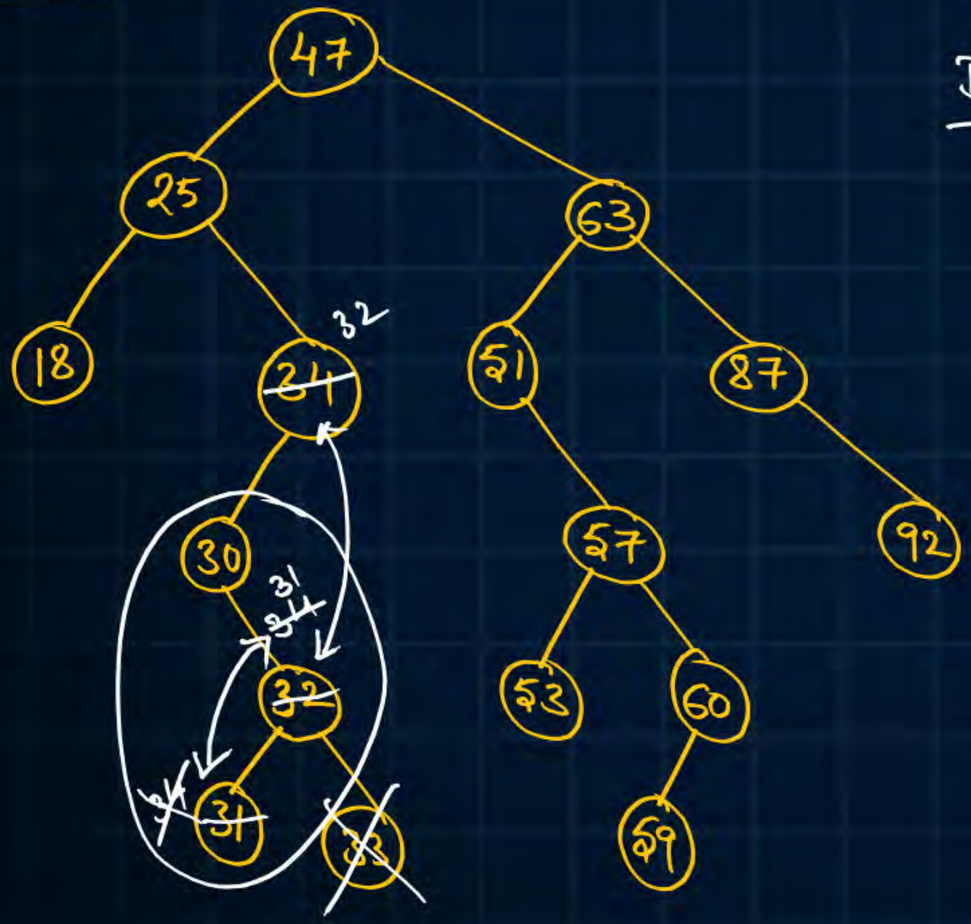
1) Delete a Node with zero children ⇒ Simply Delete.

2) Delete a Node with 1 child
   - → Left child : Swap Node with Inorder Predecessor (Maximum of Left Subtree), Delete
   - → Right child : Swap Node with Inorder Successor (minimum of Right Subtree), Delete

3) Delete a Node with 2 children
   - 1) Swap Node with Inorder Successor
   - 2) Repeat until Node becomes Leaf Node
   - 3) Delete it.

Binary Search Tree

Example :



Delete 33 : Simply Delete it

Delete 34 : Swap [34, Maximum of left Subtree = 32], Swap 34 and 31

Delete 47 (Node with 2 children)

Swap 47, Inorder Successor = 51

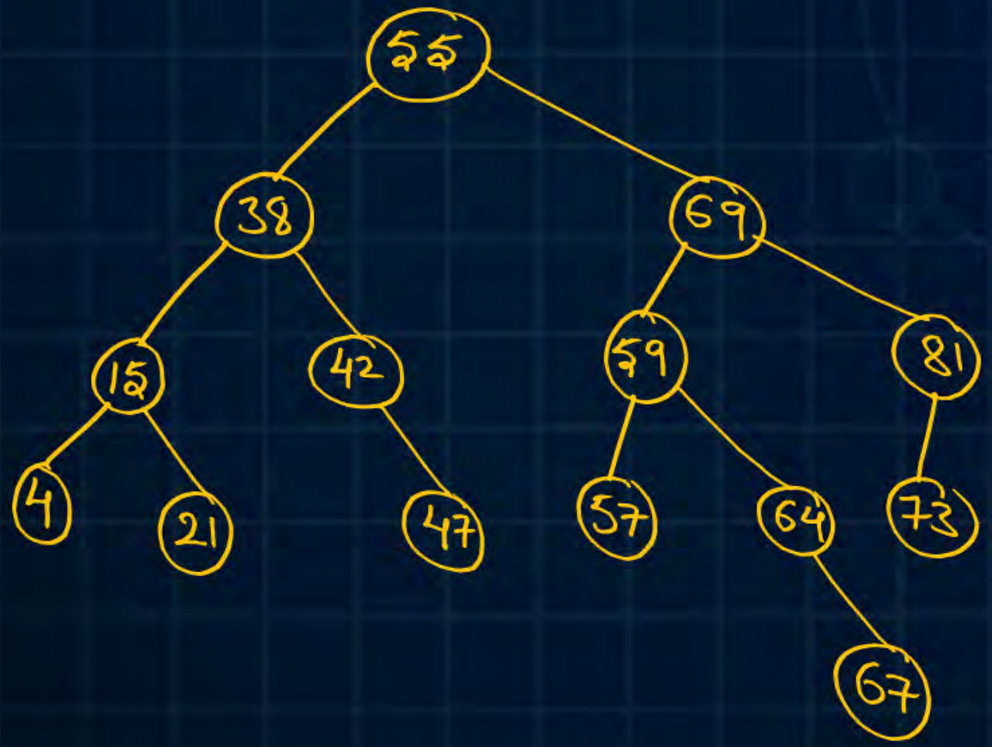
Swap 47, In order Successor = 53

Delete 47

Binary Search Tree

- In order Traversal of a BST will always result elements in the ascending order.

Example :



In order Traversal :

4, 15, 21, 38, 42, 47, 55, 57, 59, 64, 67, 69, 73, 81

Binary Heap

— A Binary Tree, that satisfy 2 conditions below (or) Properties is said to be a Binary Heap.

1) Structuring (or) Shape Property : It must be a Complete Binary Tree.

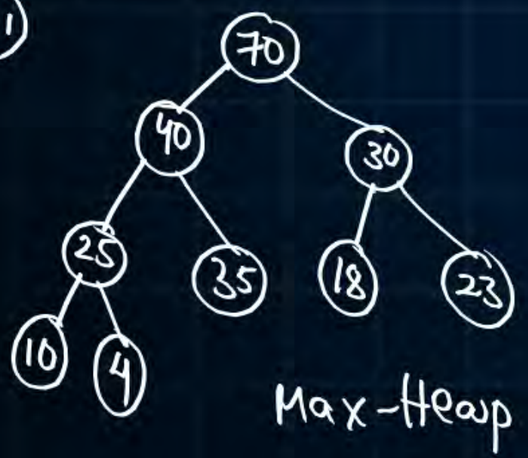
2) Ordering (or) Heap Property : Each Parent Value > All children Values ⇒ Max-Heap

(OR)

Each Parent Value < All children Values ⇒ min-heap.

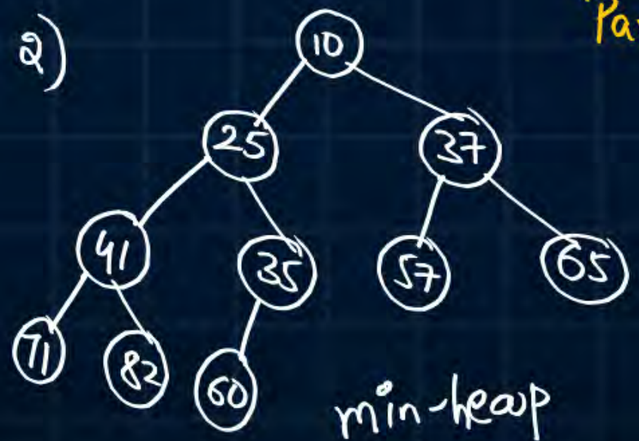
Examples :

1)



Max-Heap

2)



min-heap

3)

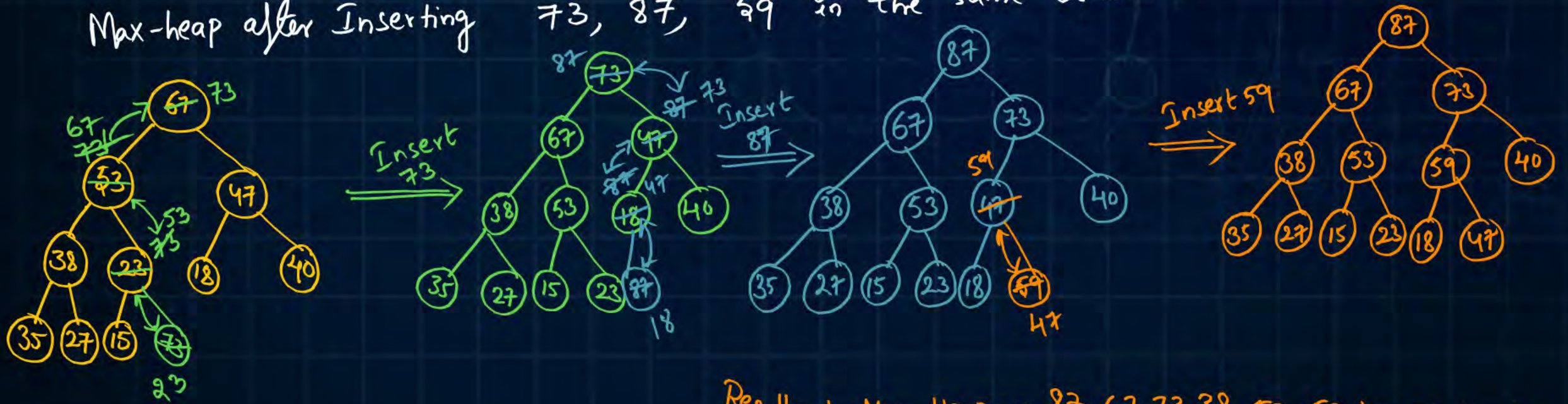
Not a CBT

⇒ Not a Binary Heap.

Binary Heap

Insertion into Heap

#Q. Consider a Max-Heap with elements 67, 53, 47, 38, 23, 18, 40, 35, 27, 15. The resultant Max-heap after Inserting 73, 87, 59 in the same order is _____



Resultant Max-Heap == 87, 67, 73, 38, 53, 59, 40, 35, 27, 15, 23, 18, 47

Binary Heap

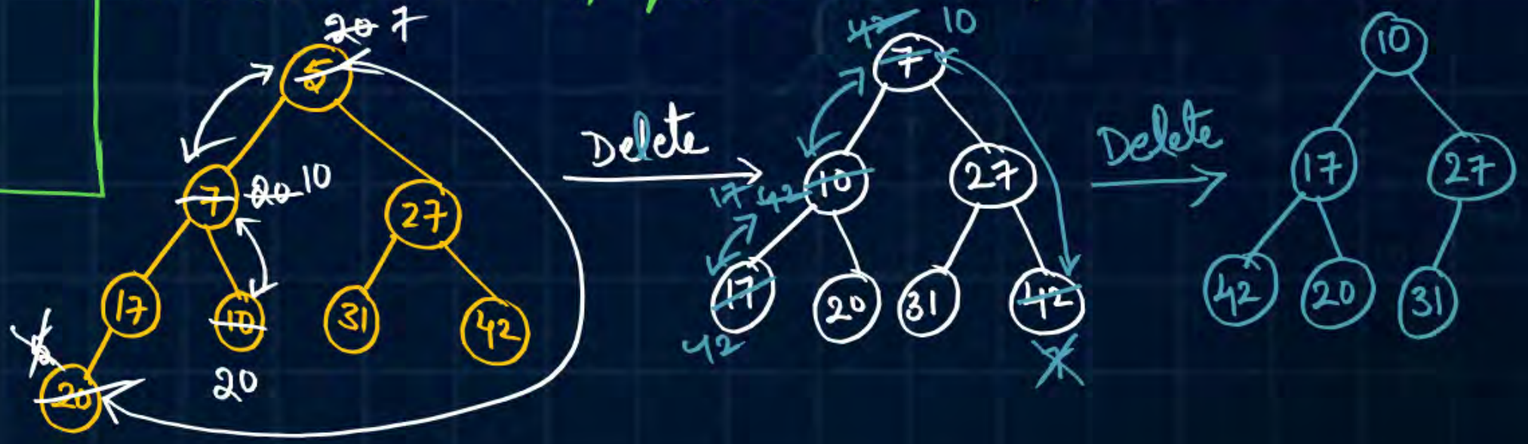
Deletion from Binary Heap :

- Deletion in a Heap by default Performed at root Node only, To Preserve CBT Property.

1) Swap root Node with last leaf
2) Delete Node
3) Heapify (Compare and Swap).

Ex: Consider a min-heap, with Elements : 5, 7, 27, 17, 10, 31, 42, 20.

The Resultant min-heap, after 2 Deletion operations is _____



The Resultant min-heap : 10, 17, 27, 42, 20, 31

Binary Heap

Home-work

#Q. Consider a Max-heap with Elements: 85, 72, 63, 57, 42, 60, 38, 43, 19. The Resultant Max-Heap after following operations, in the same order is _____

1) Insert 80
2) Delete
3) Insert 93
4) Delete

Post Your Homework Answers / Queries / Doubts @

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Summary

- Binary Search Tree
  - Construction
  - Insertion
  - Deletion
- Binary Heap
  - Insertion
  - Deletion


Thank
THANK
Keep Hustling!