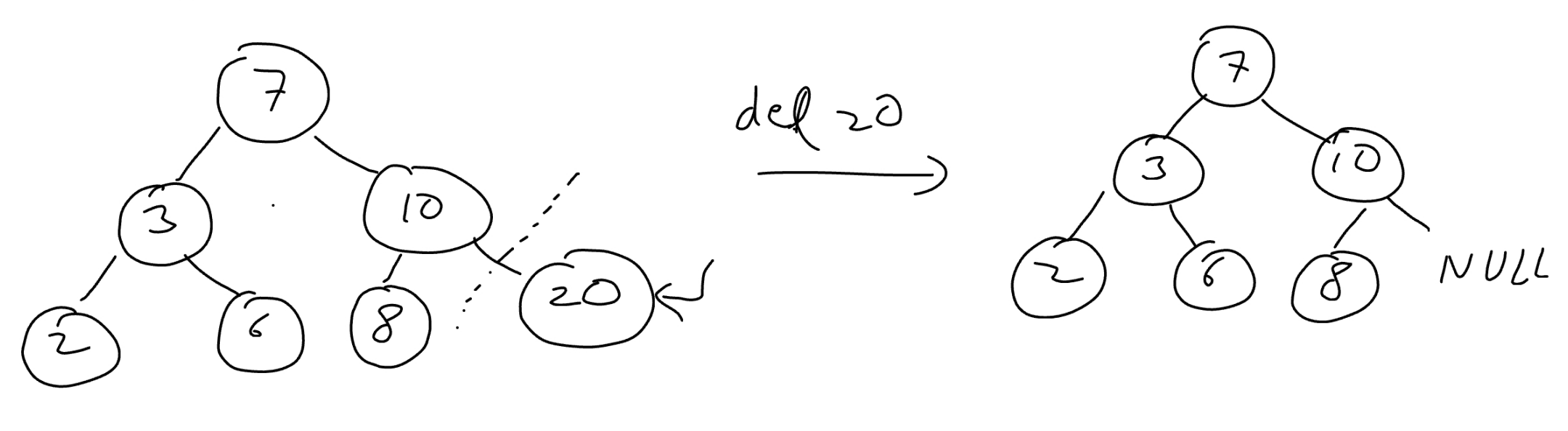
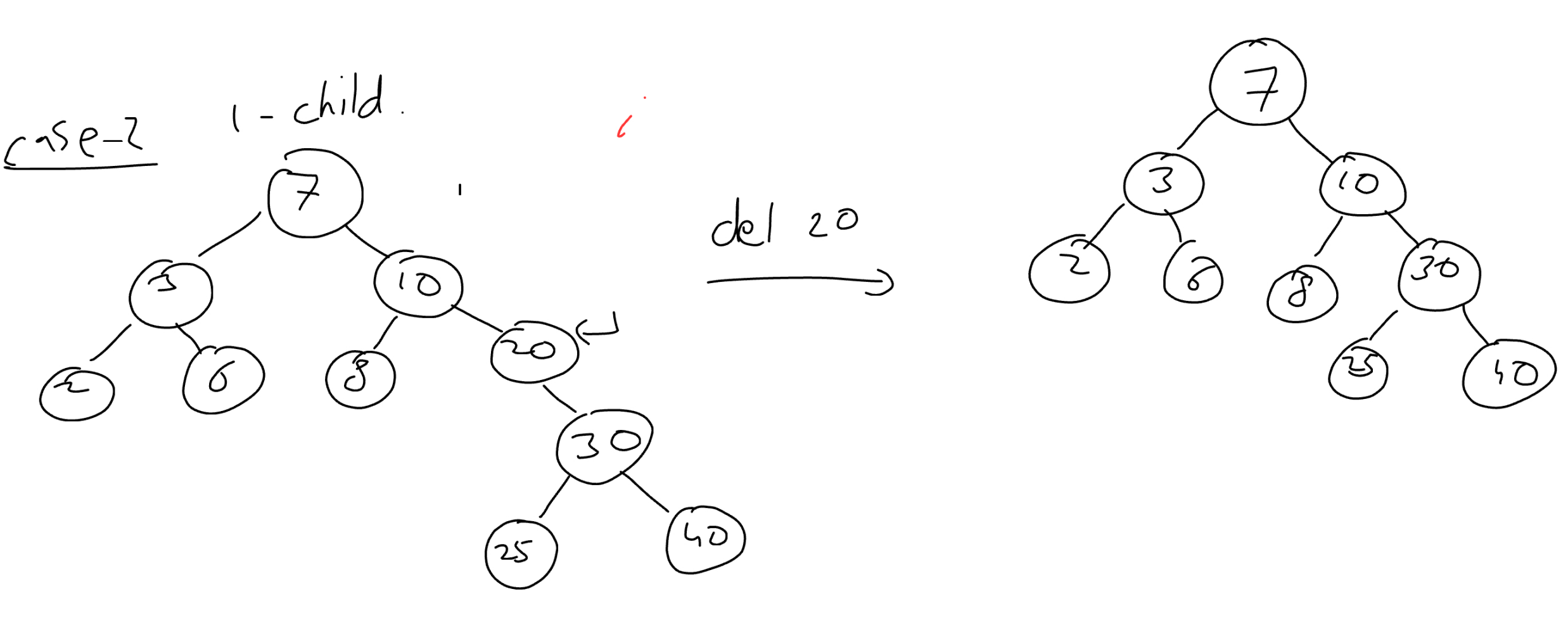
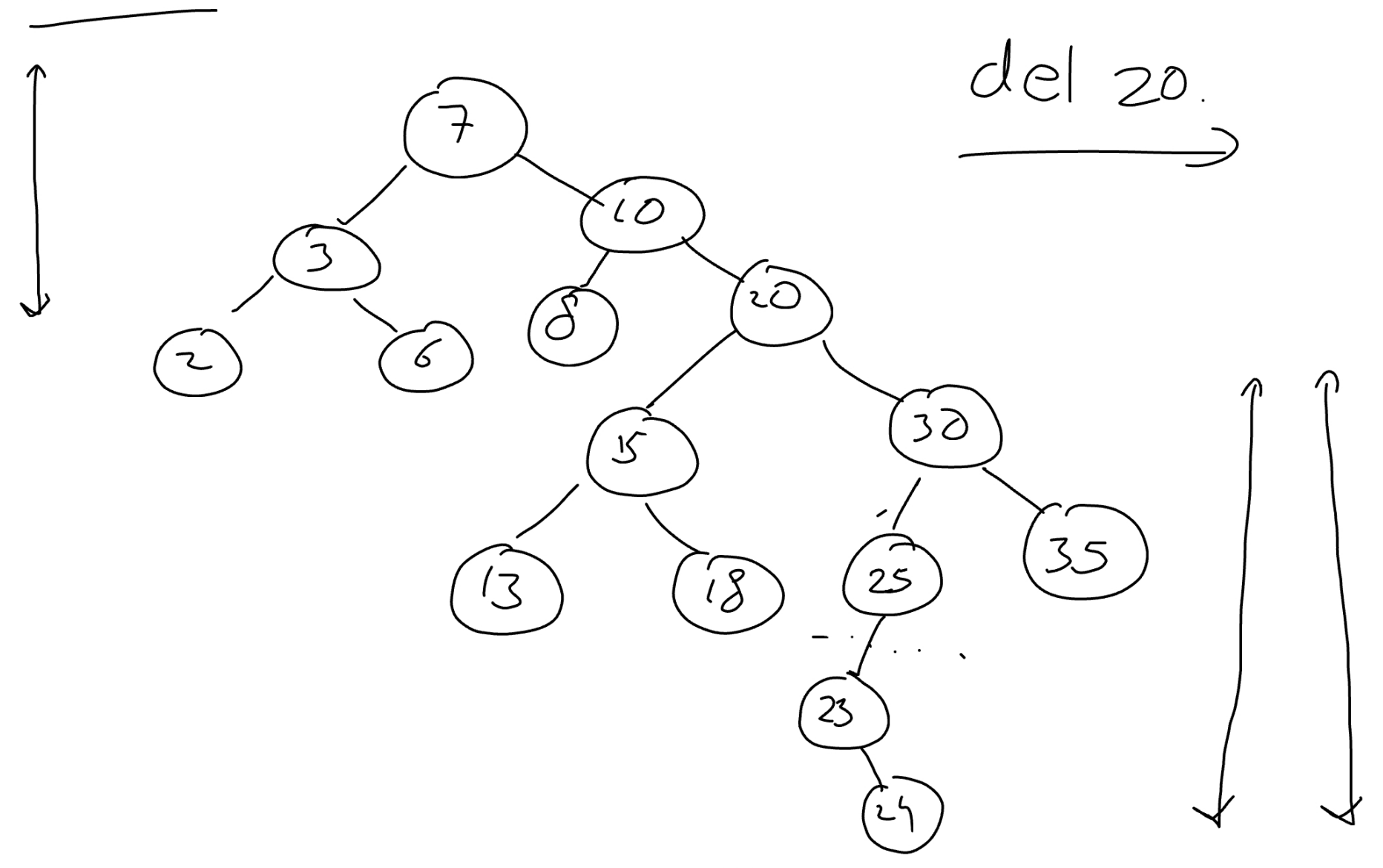
case-1 0 child


7
3
10
2
6
8
20
del 20
7
3
10
2
6
8
NULL

case-2 1-child

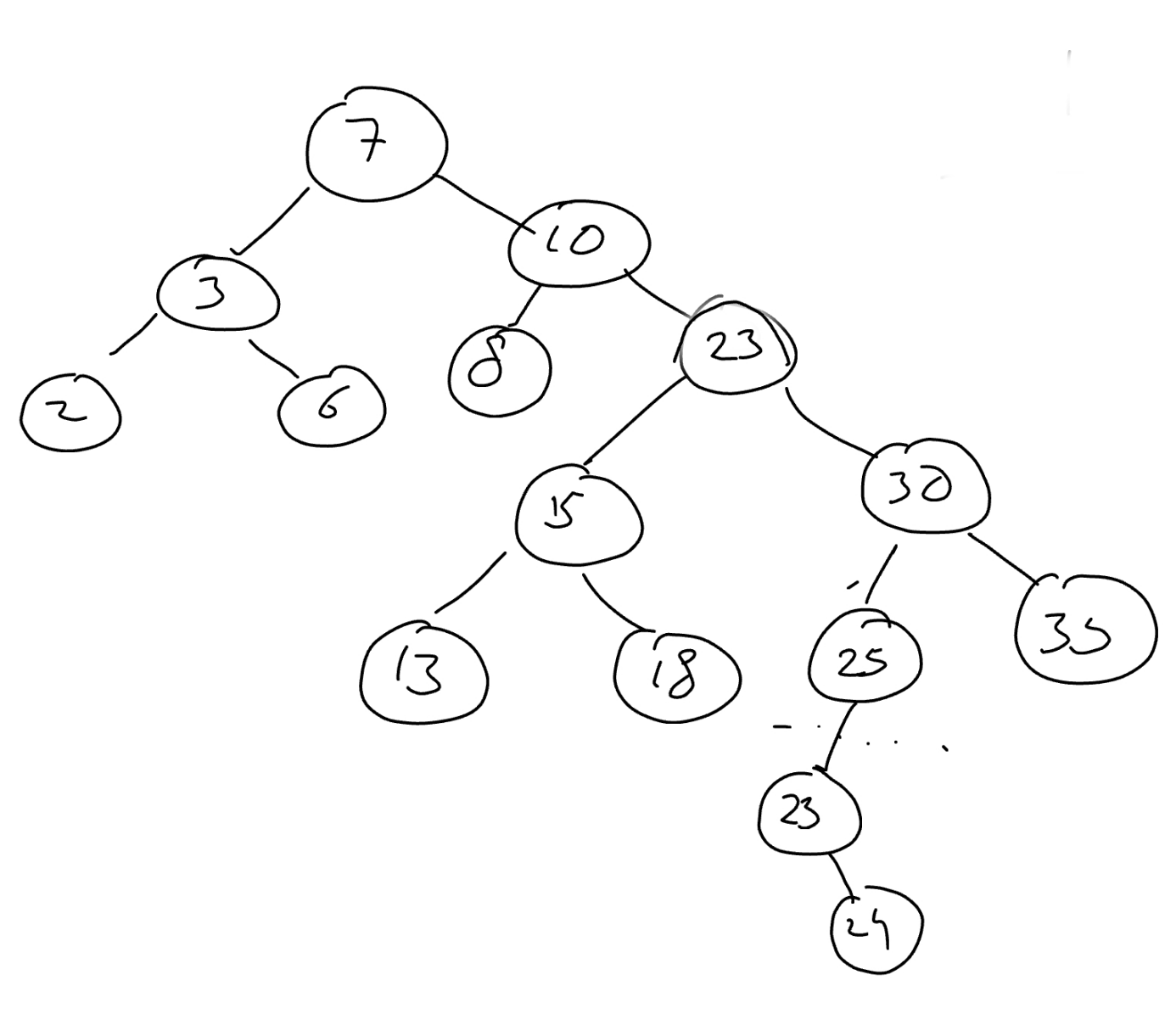

7
3
10
2
6
8
20
30
25
40
del 20
7
3
10
2
6
8
30
25
40

case-3.

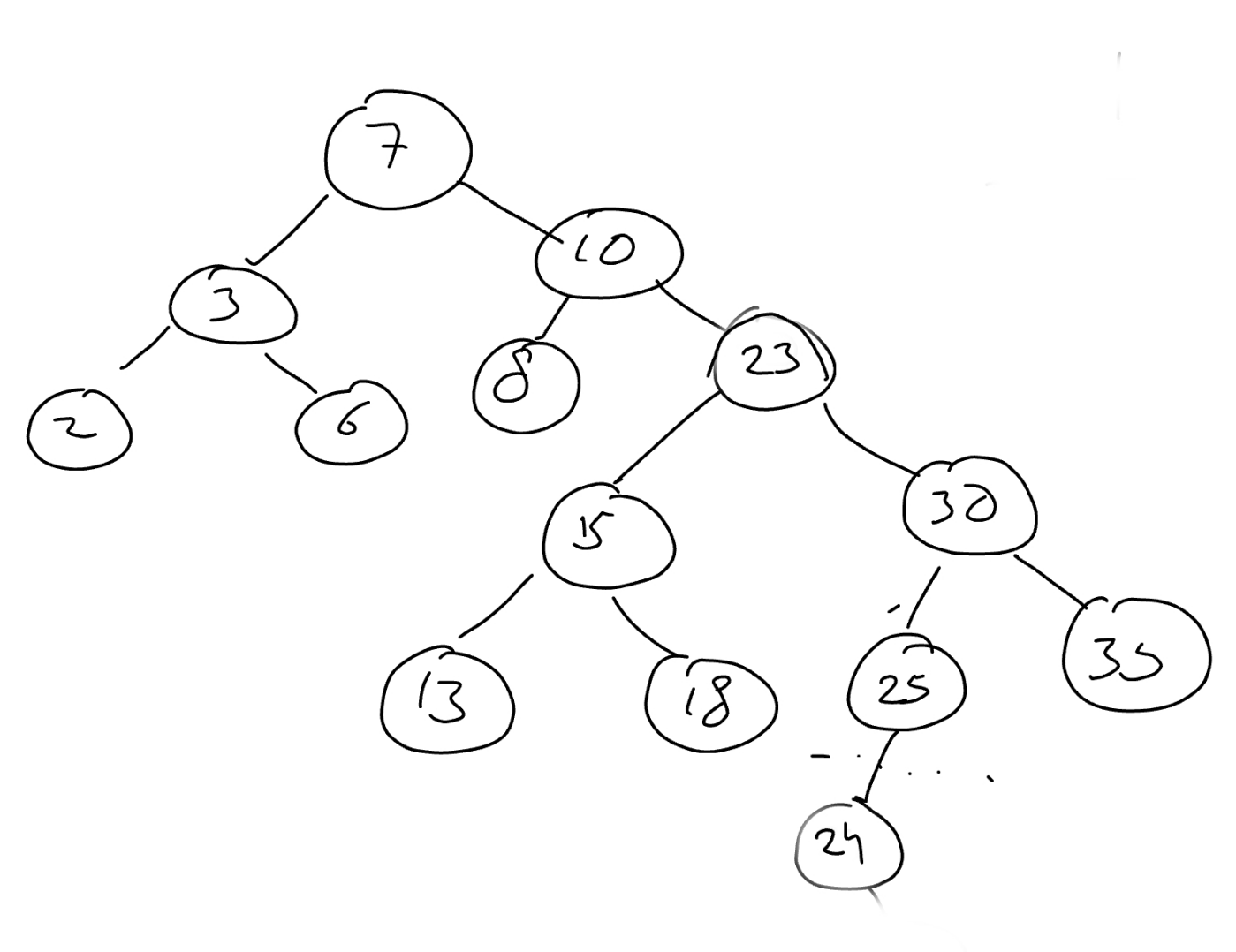

del 20.
7
3
10
2
6
8
20
15
30
13
18
25
35
23
24

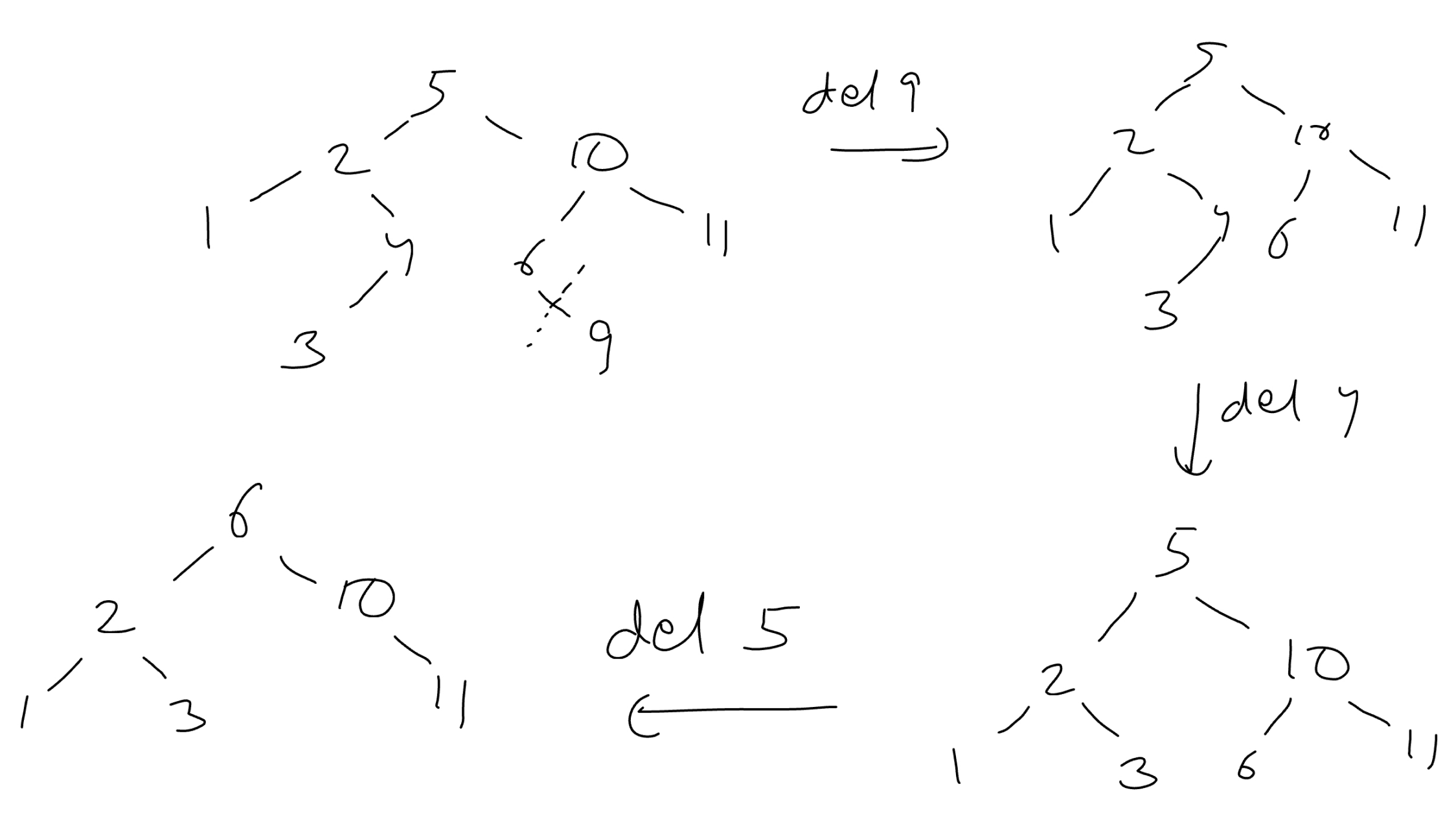
TC: O(H).
AS; O(H)

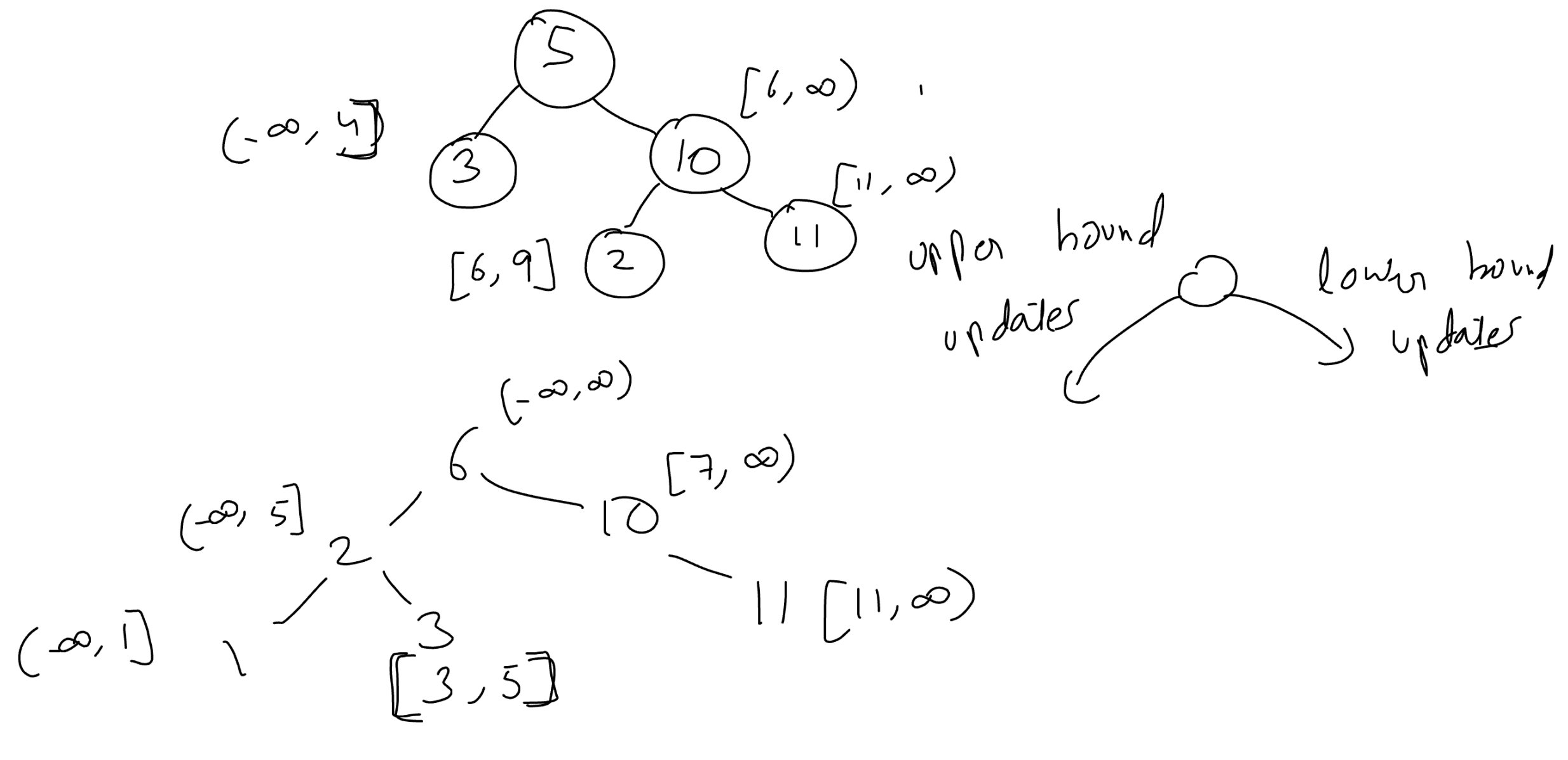
Step-1
Replace 20 with its inorder successer.


7
3
10
2
6
8
23
15
30
13
18
25
35
23
24

step-2. Del the inorder succ.

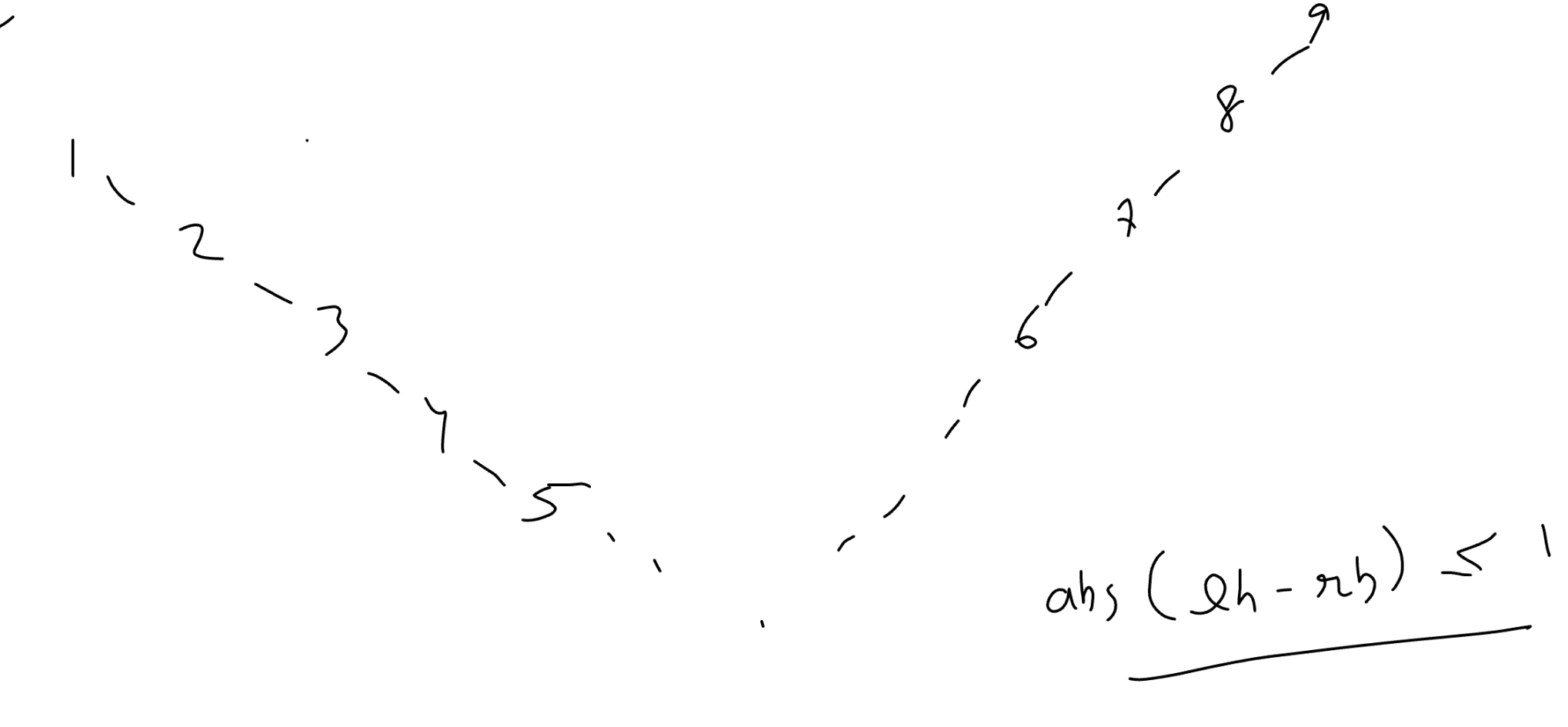

7
3
10
2
6
8
23
15
30
13
18
25
35
24


5
2
10
1
4
6
11
3
9
del 9
5
2
10
1
4
6
11
3
del 4
5
2
10
1
3
6
11
del 5
6
2
10
1
3
11


(-∞, ∞)
5
(-∞, 4]
3
10
[6, ∞)
[6, 9]
2
11
[11, ∞)
upper bound updates
lower bound updates
(-∞, ∞)
6
(-∞, 5]
2
10
[7, ∞)
(∞, 1]
1
3
[3, 5]
11 [11, ∞)

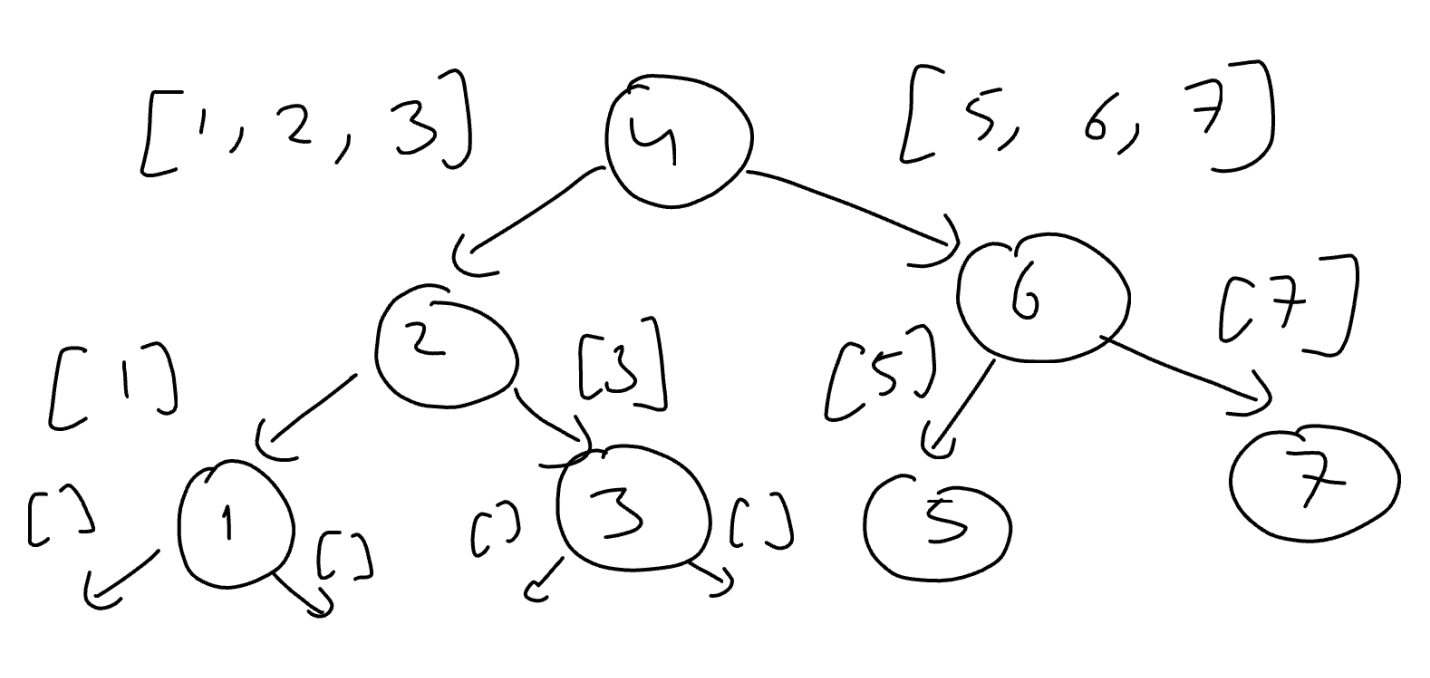
TC: O(n)
AS: O(H)

[1, 2, 3, 4, 5, 6, 7] ~~8, 9~~.

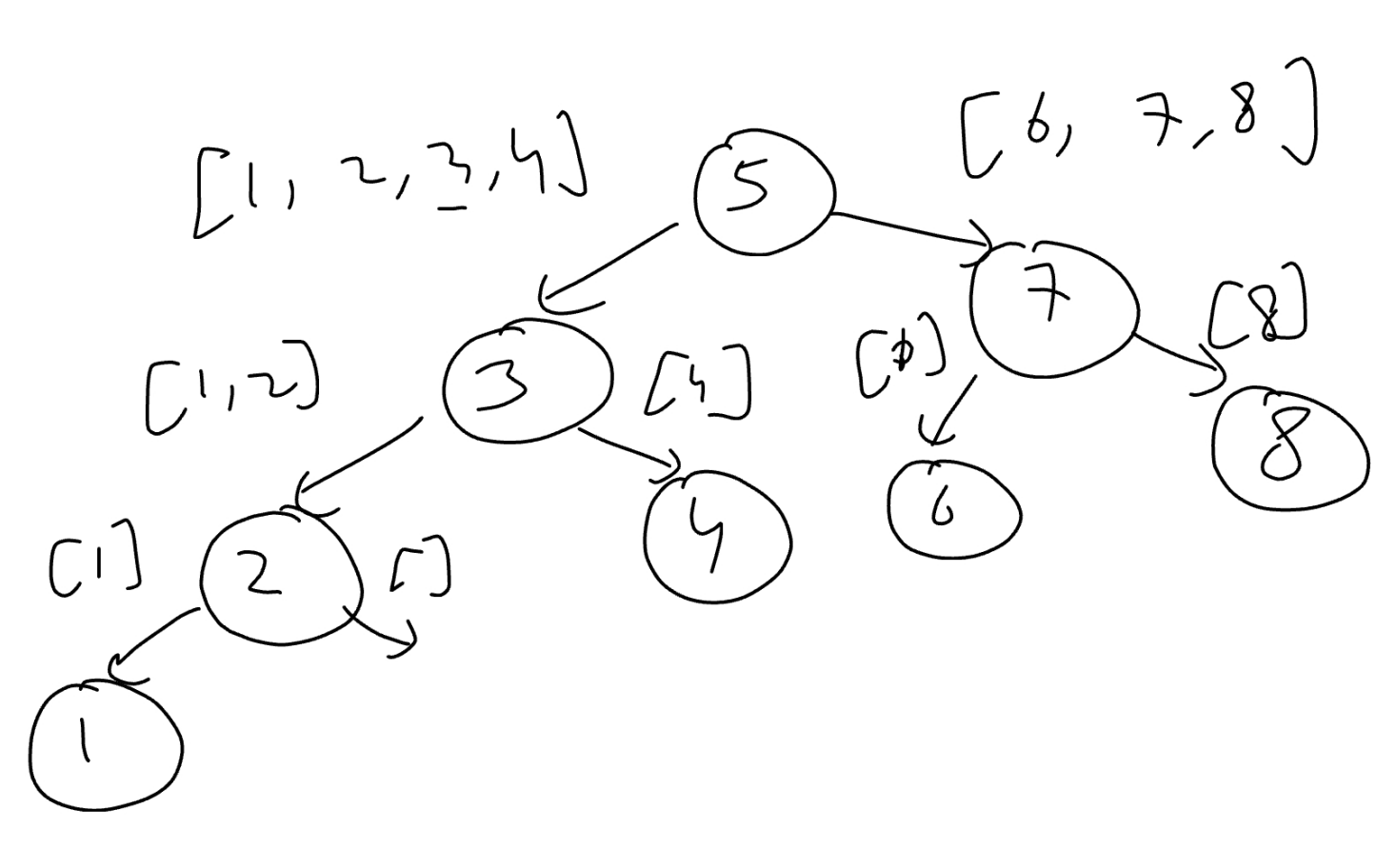


abs (lh - rh) ≤ 1

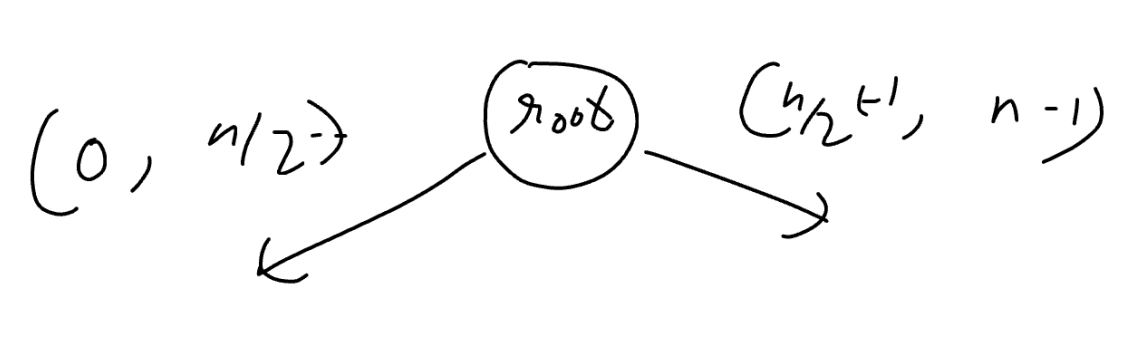
[1, 2, 3, 4, 5, 6, 7]

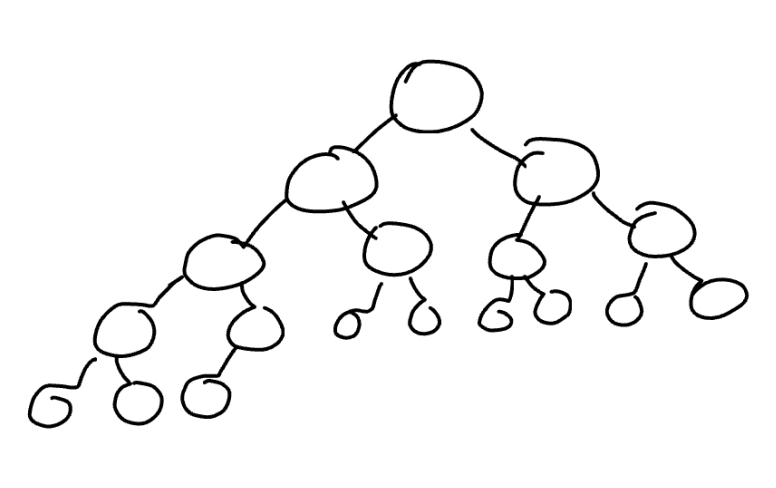

[1, 2, 3]
4
[5, 6, 7]
2
[1]
[3]
6
[5]
[7]
[]
1
[]
[]
3
[]
5
7

[1, 2, 3, 4, 5, 6, 7, 8].

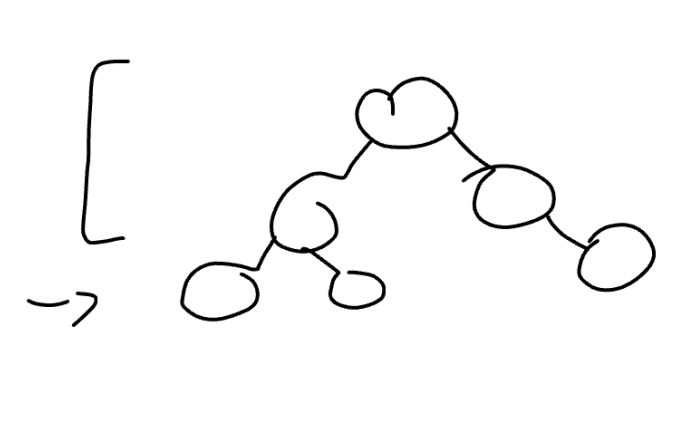

[1, 2, 3, 4]
5
[6, 7, 8]
3
[1, 2]
[4]
7
[6]
[8]
2
[1]
[]
4
6
8
1

l h
(0, n-1)

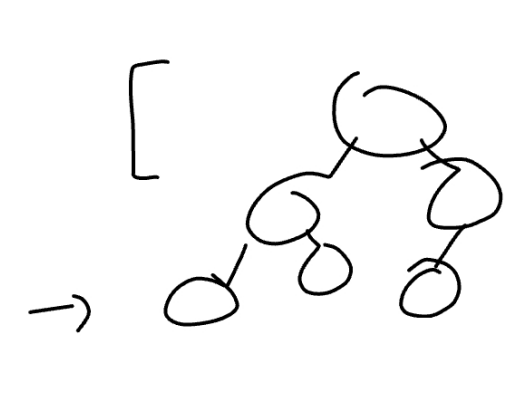

(0, n/2-1)
root
(n/2+1, n-1)



→ Complete BT.



→ Not a complete BT.

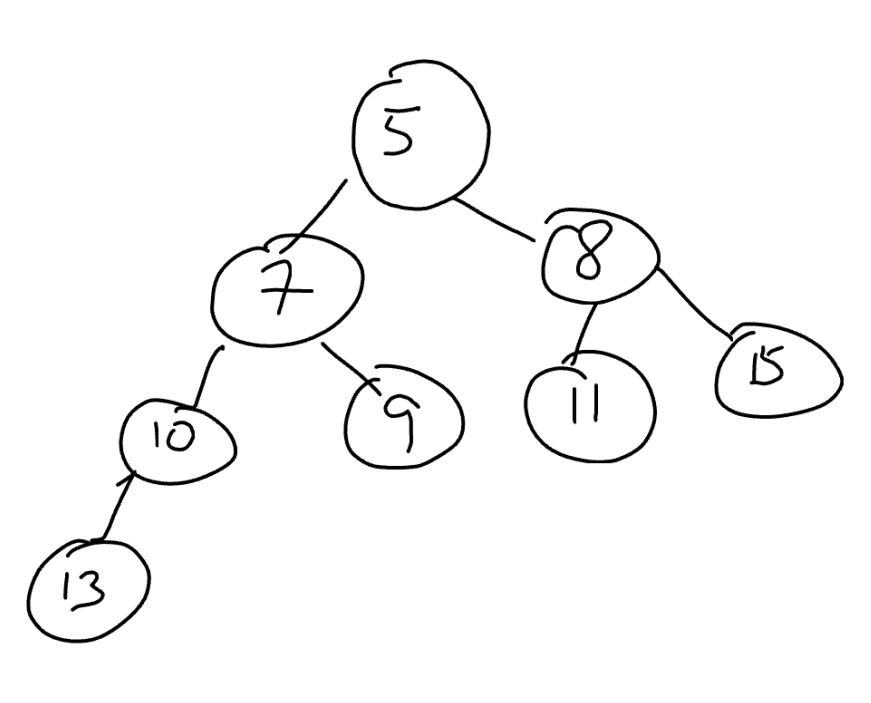


→ Complete BT.

Min-Heap

Max-Heap

Similar.

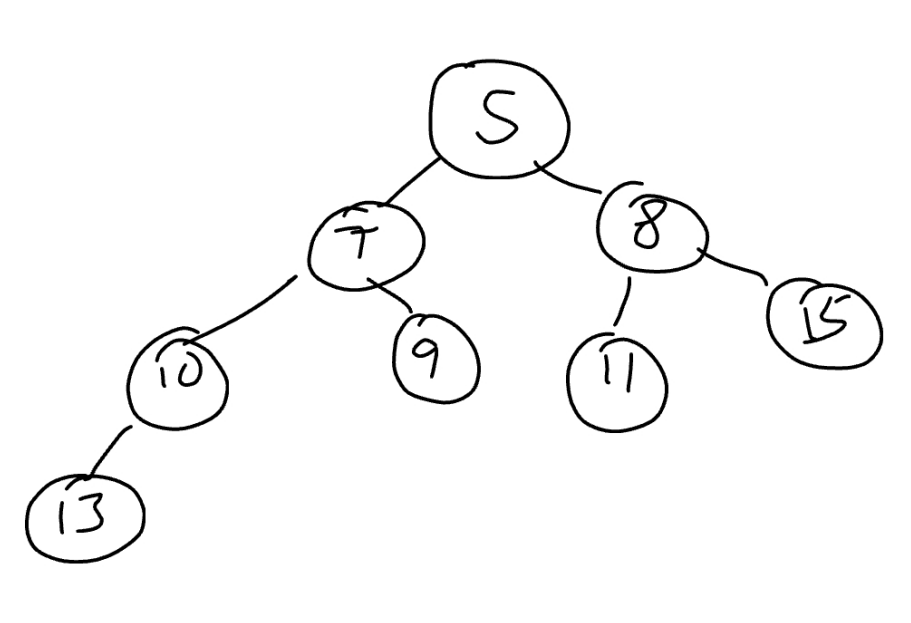

5
7
8
10
9
11
15
13

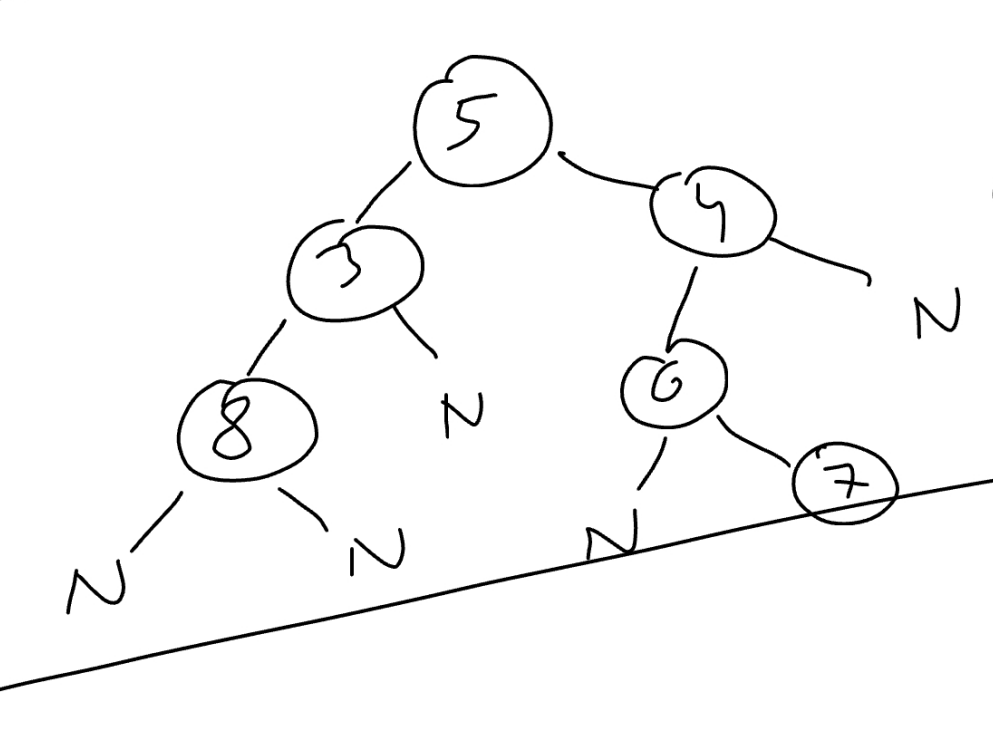
i

left: 2i + 1
right: 2i + 2
parent: $\frac{(i-1)}{2}$

#

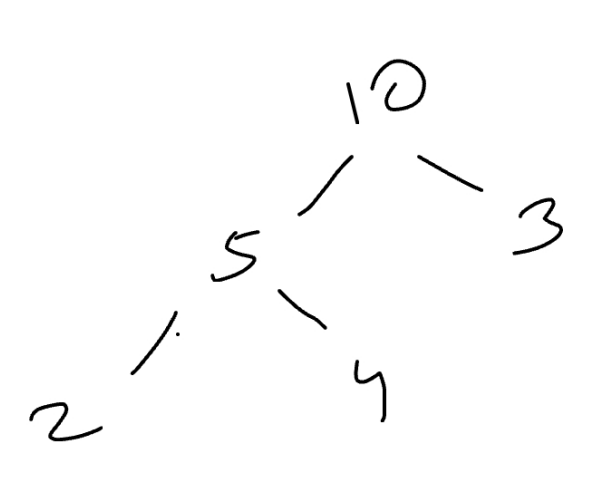
0	1	2	3	4	5	6	7
5	7	8	10	9	11	15	13


5
7
8
10
9
11
15
13


5
3
4
8
N
N
6
N
N
N
7
N

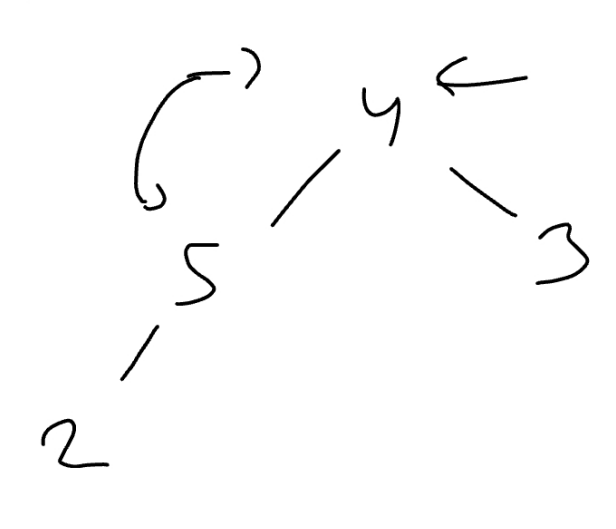
[5, 3, 4, 8, N, 6, N, N, N, N, 7]

Delete



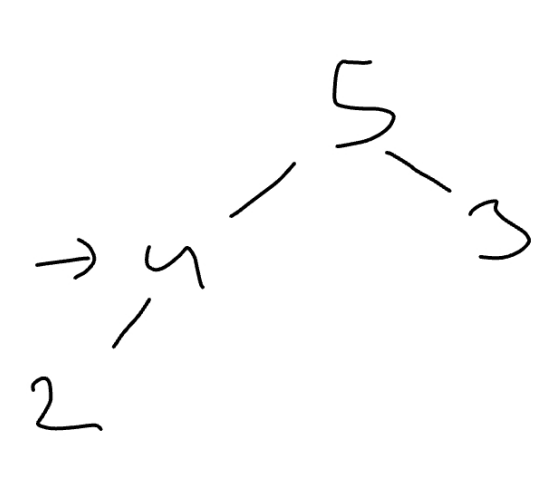
[10, 5, 3, 2, 4].

Step-1

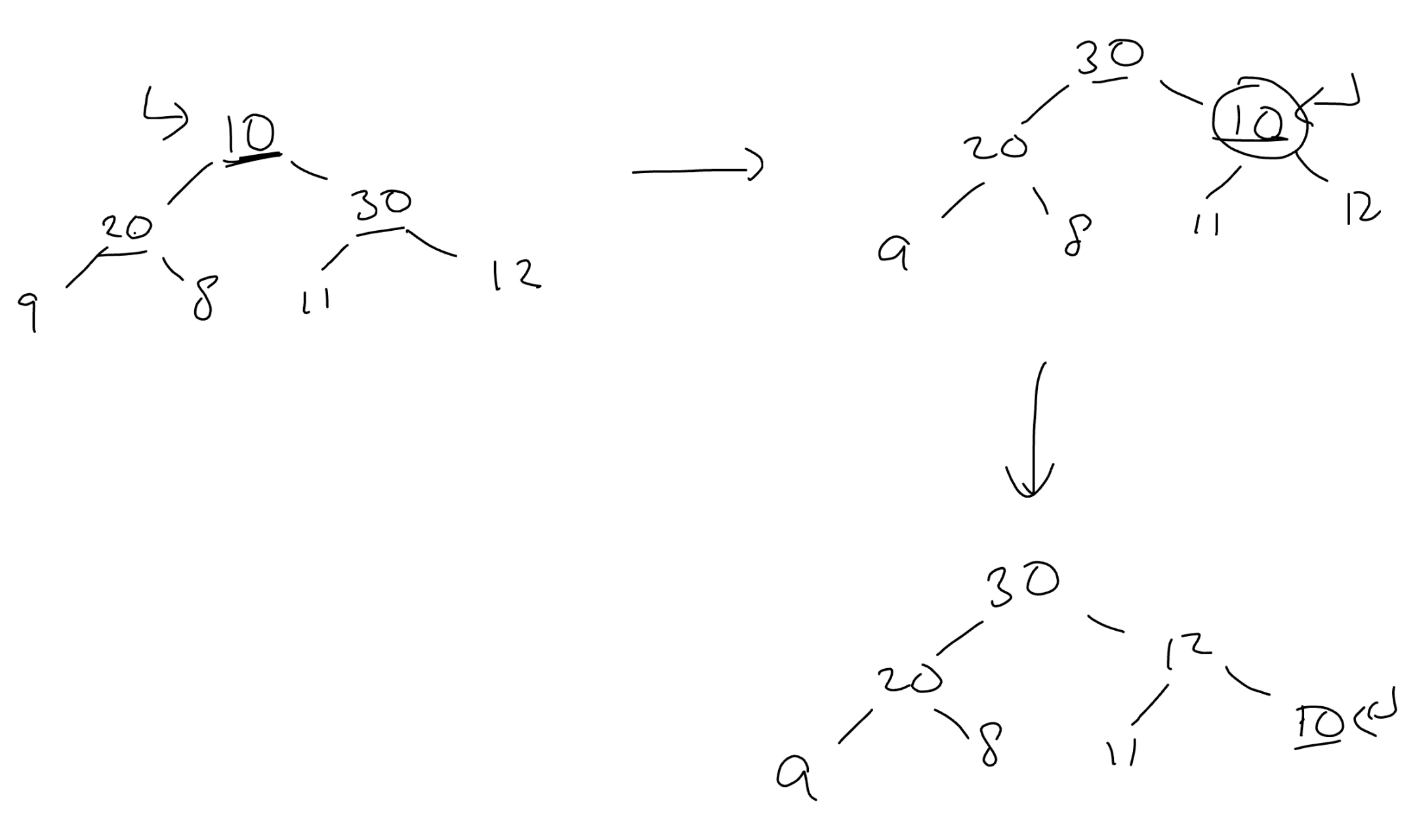


[4, 5, 3, 2]

step-2. Top-Down Heapify the root

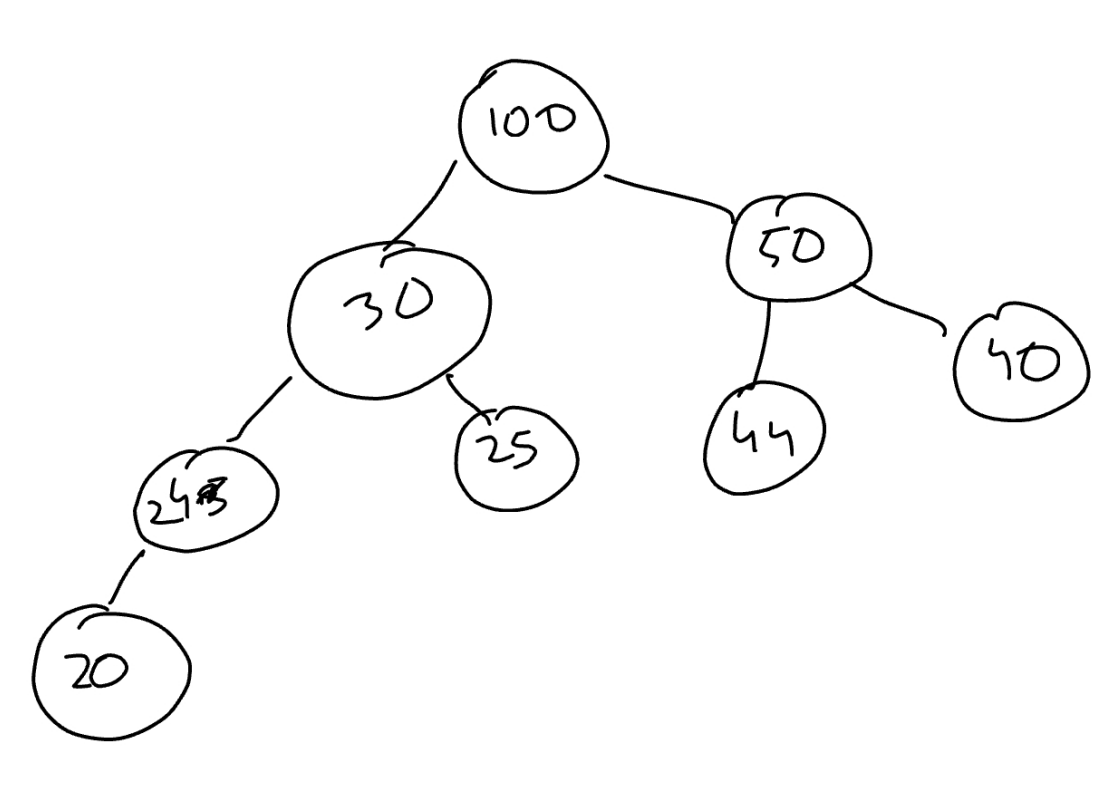


[5, 4, 3, 2].

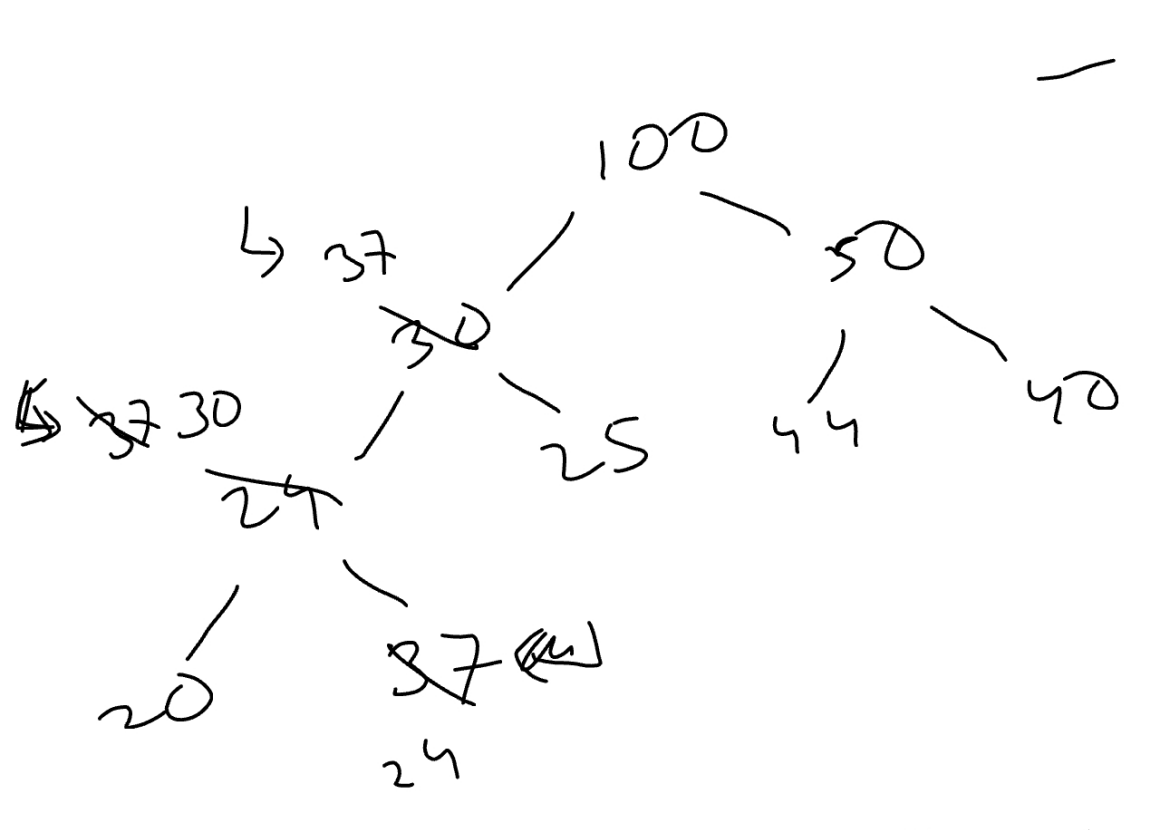

10
20
30
9
8
11
12
30
20
10
9
8
11
12
30
20
12
9
8
11
10

TC: O(log n)
AS: O(log n).

Insert: 37


100
30
50
24
25
44
40
20

[100, 30, 50, 24, 25, 44, 40, 20]


100
37
~~30~~
50
~~37~~ 30
~~24~~
25
44
40
20
~~37~~
24

[100, 37, 50, 30, 25, 44, 40, 20, 24].

TC: O(log n).
AS: O(log n).