PW SKILLS

Heaps

Lecture 2

Today's checklist

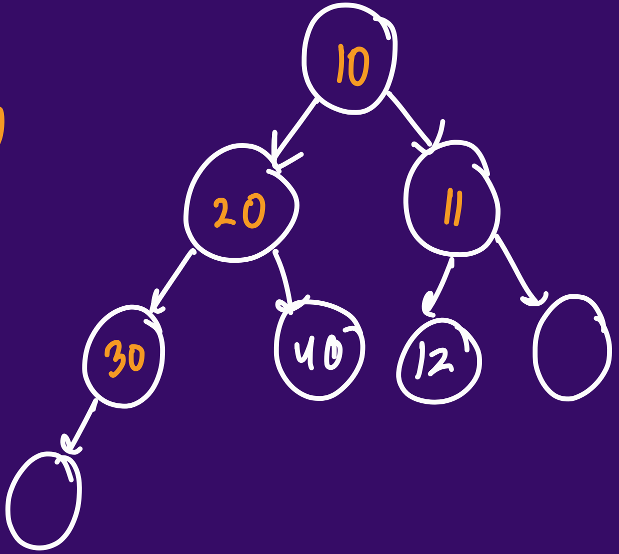
1. Heaps Visualisation (MaxHeap and MinHeap)
2. Implementation of MinHeap by Array
3. Heapify Algorithm
4. Heap Sort
5. Questions on heaps

Heaps Visualisation (Binary tree)

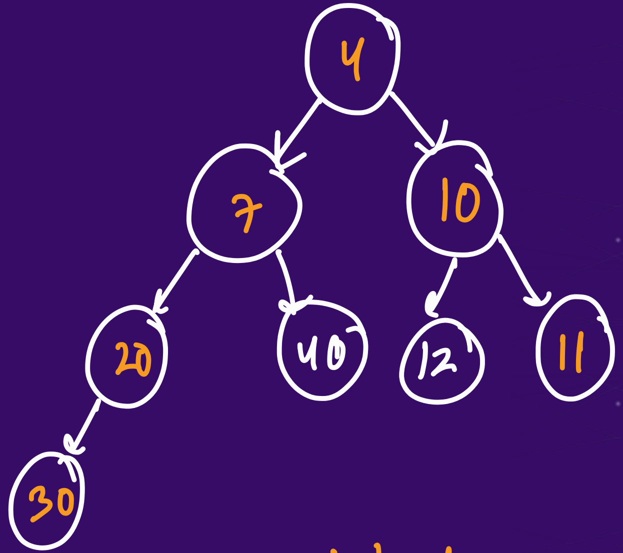
For Ex: Lets do minheap

push(10)
push(20)
push(11)
push(30)
push(40)
push(12)
push(4)
push(7)

pop()
pop()



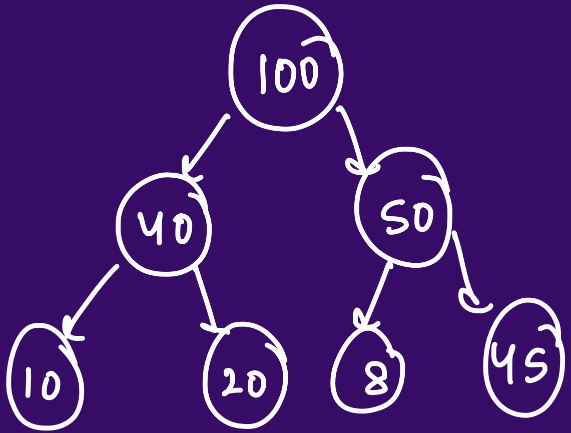
minheap



minheap

Heaps Visualisation

Maxheap

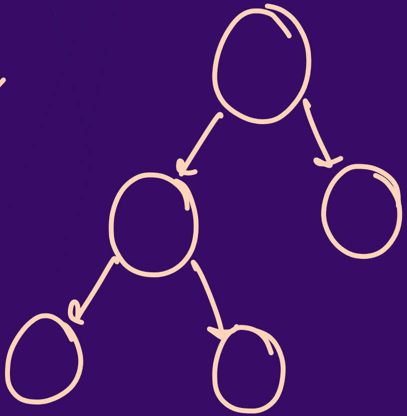


H.W. Visualise & draw maxheap via a CBT.

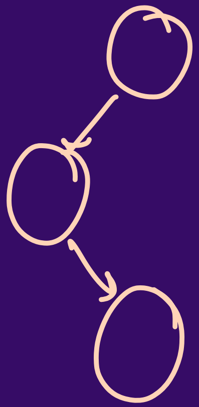
Heaps Visualisation

What is a complete Binary Tree ?

CBT ✓

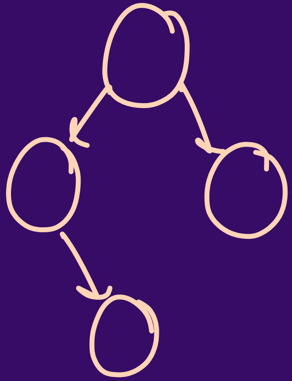


levels = 2



levels = 3

✗



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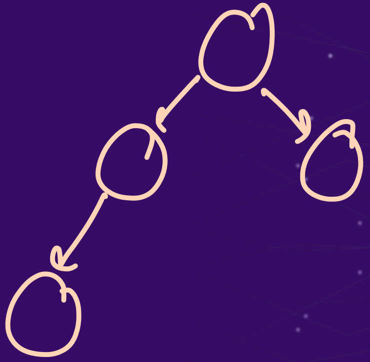


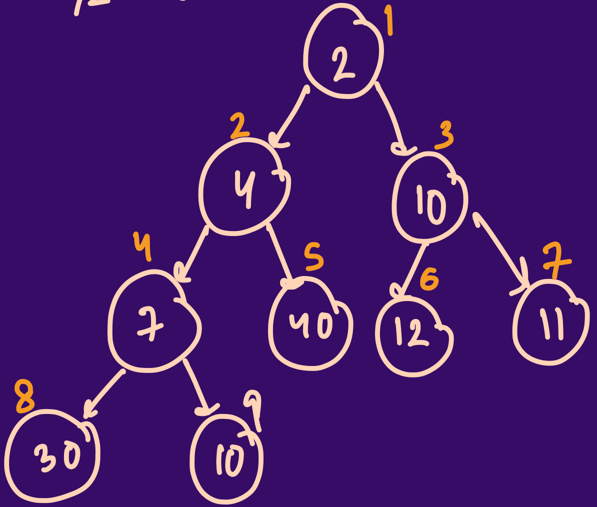
✓

Ques:

Q1 : Implement a MinHeap by Array (Visualise it with a CBT)

push(10) ✓
push(20) ✓
push(11) ✓
push(30) ✓
push(40) ✓
push(12) ✓
push(4) ✓
push(7) ✓
push(2) ✓

0	1	2	3	4	5	6	7	8	9	10	11	12	
☒	2	4	10	7	40	12	11	30	20				. . .
i/2	i												



for a node at i,
then,

left child = $2*i$

right child = $2*i+1$

parent = $i/2$

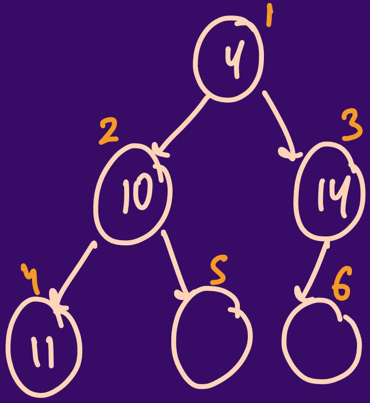
Ques:

Q1 : Implement a MinHeap by Array

push(10)
push(2)
push(14)
push(11)
push(1)
push(4)
pop()
pop()

0	1	2	3	4	5	6	7	8	9	10	11	12
☒	4	10	14	11	~~14~~	~~14~~						
					idx					l	r	

. .



minheap

Homework :

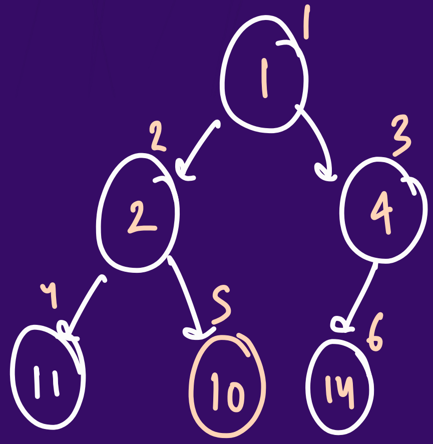
Implement a MaxHeap using Array

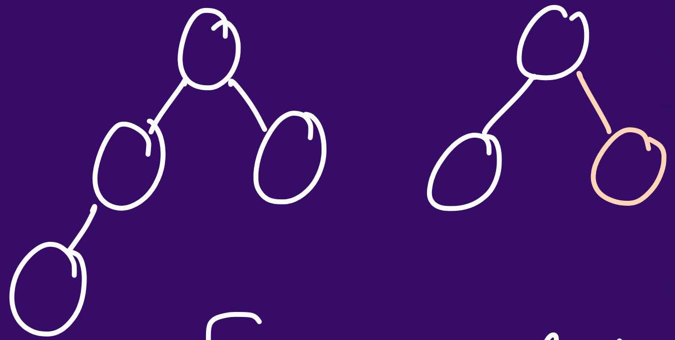
Heapify Algorithm

↪ Convert given array to Heap

$$\begin{array}{ccccccc} & 1 & 2 & 3 & 4 & 5 & 6 \\ arr = \{ & 1, & 2, & 4, & 11, & 10, & 14 \ \} \\ & & & & & \uparrow & \end{array}$$

Convert it into minheap





$$\left[\underset{\text{even}}{\underset{\downarrow}{\frac{n}{2}}} , \ \underset{\text{odd}}{\underset{\downarrow}{\frac{n}{2}}} + 1 \ \text{leaf nodes} \right]$$

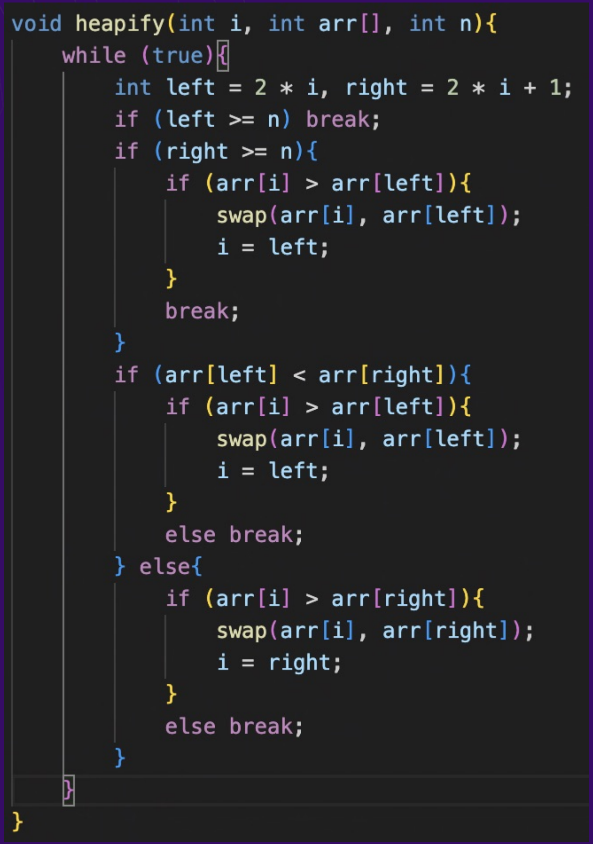
Heapify Algorithm

```
for (int i = n/2 ; i>=1 ; i--){

        heapify(i, arr, n);

}
```

↓

pop()'s rearrangement

Heapify Algorithm



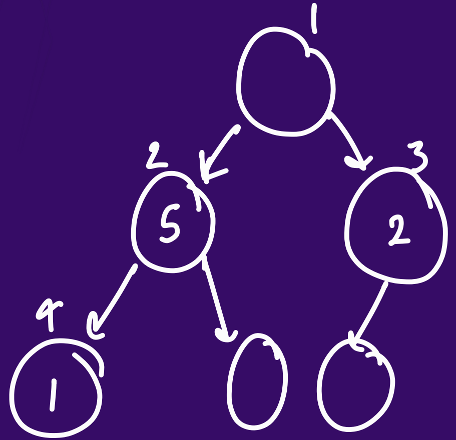
```
void heapify(int i, int arr[], int n){
    while (true){
        int left = 2 * i, right = 2 * i + 1;
        if (left >= n) break;
        if (right >= n){
            if (arr[i] > arr[left]){
                swap(arr[i], arr[left]);
                i = left;
            }
            break;
        }
        if (arr[left] < arr[right]){
            if (arr[i] > arr[left]){
                swap(arr[i], arr[left]);
                i = left;
            }
            else break;
        } else{
            if (arr[i] > arr[right]){
                swap(arr[i], arr[right]);
                i = right;
            }
            else break;
        }
    }
}
```

Heap Sort (A joke) (use pq STL)

For 2x: an array is given, sort it using heap.

arr = { 10, 1, 2, 20, 5, 8 }

8 10 20



Can be done by minheap & maxheap

T.C. = $O(n * \log n)$

↓

Merge & Quick Sort

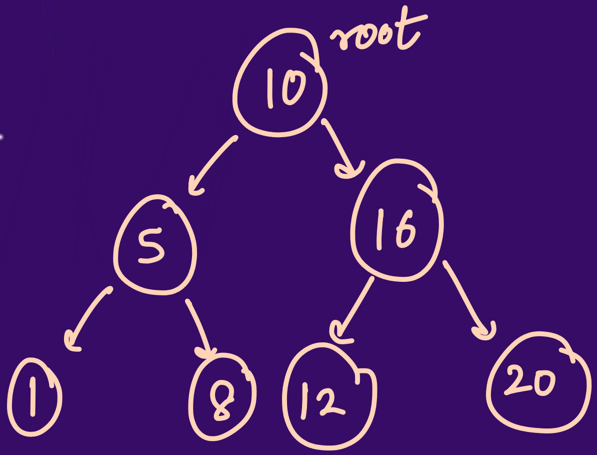
S.C. = $O(n)$

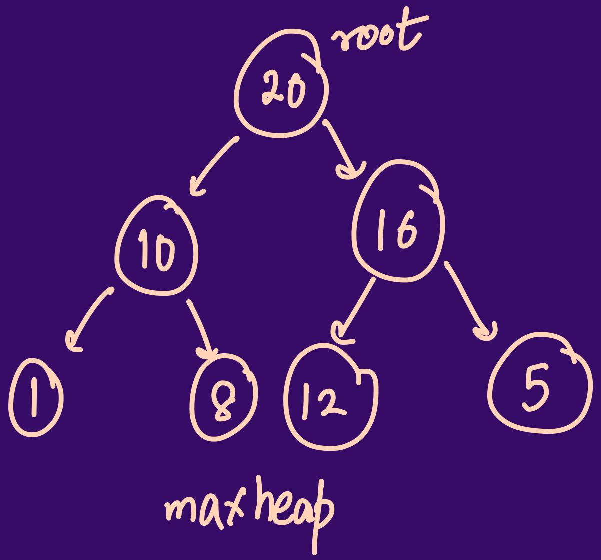
Ques:

inorder

Q2 : Convert BST to MaxHeap

sorted array



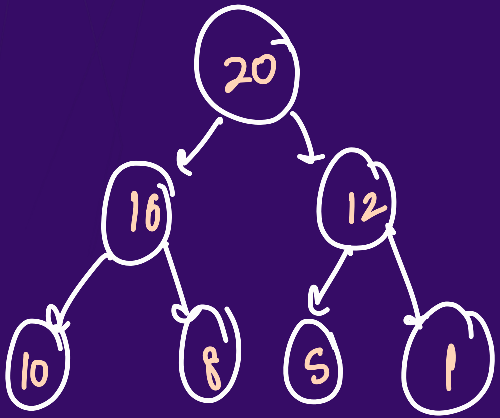


1 5 8 10 12 16 20

Ques: kk LST > RST → $\boxed{M-2}$

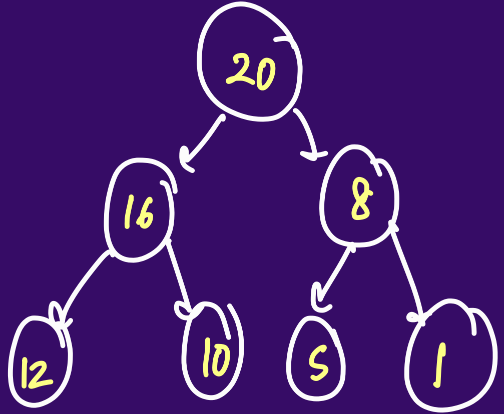
Q2 : Convert BST to MaxHeap

20 16 12 10 8 5 1



1) level wise → ek array ke elements
(↓ sorted)

20 16 12 10 8 5 1



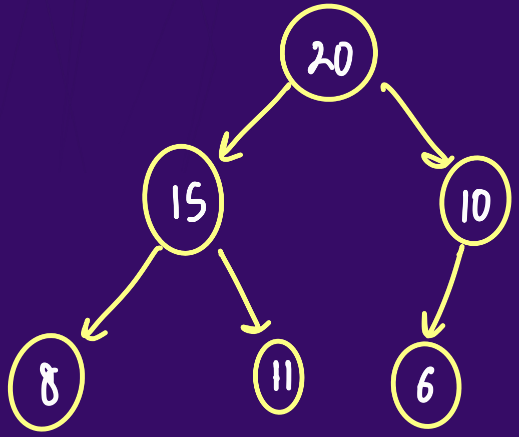
2) Pre Order wise ✓

Ques:

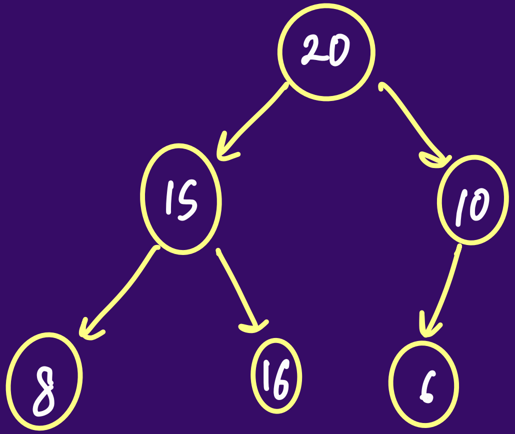
Q3 : Check if given Binary Tree is a MaxHeap or not

Condition-1 : all decendants of any node should be smaller

⇒ root->left ->val < root->val > root->right ->val



✓

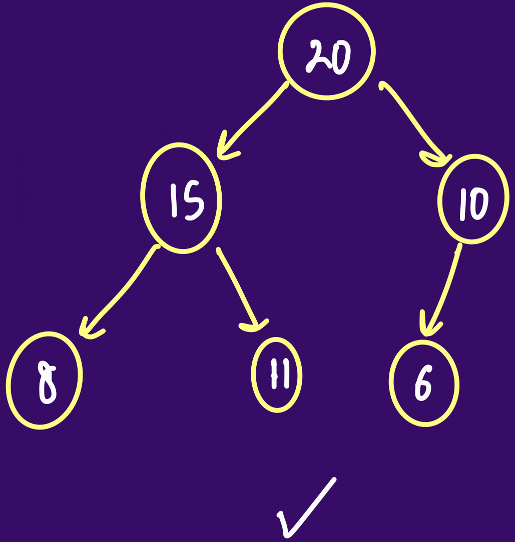


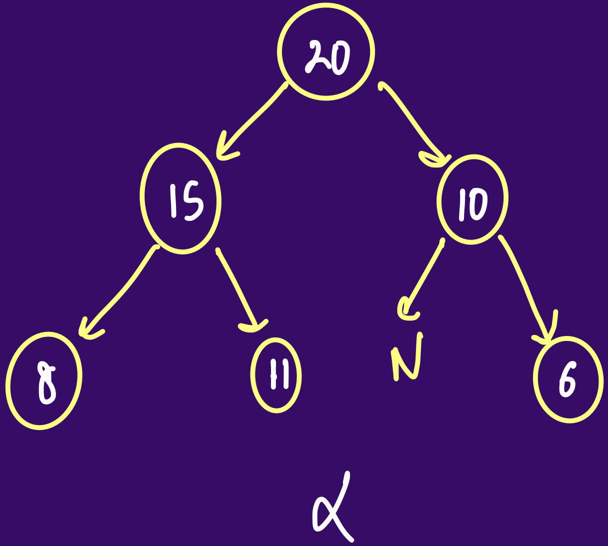
✗

Ques:

Q3 : Check if given Binary Tree is a MaxHeap or not

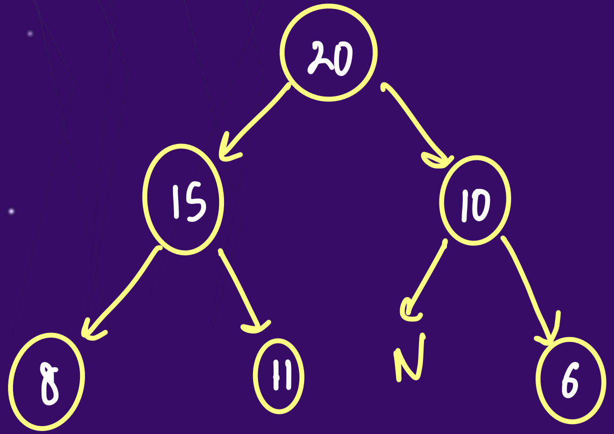
Condition-2 : It should be a CBT.





Ques:

Q3 : Check if given Binary Tree is a MaxHeap or not



Size = 6

6 N N N N

q

Count = ~~0~~ ~~1~~ 2 ~~3~~ ~~4~~ ~~5~~ 6

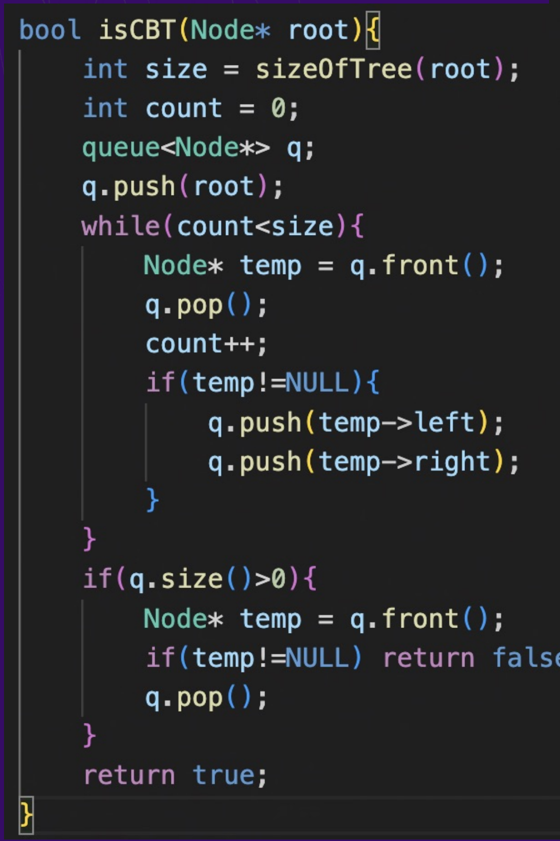
20 15 10
8
N
11

Ques:

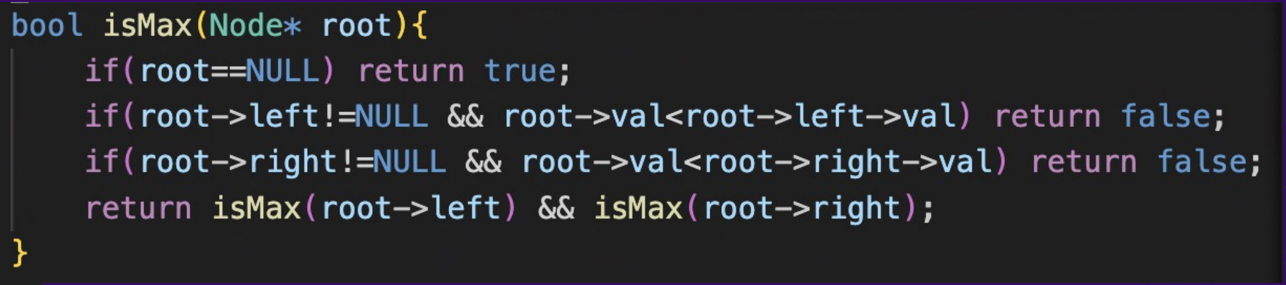
Q3 : Check if given Binary Tree is a MaxHeap or not

```
bool isCBT(Node* root){
    |
}

bool isMax(Node* root){
    |
}

if( isCBT(root) && isMax(root)) → Yes
else → No
```

Ques:



```cpp
bool isCBT(Node* root){
    int size = sizeOfTree(root);
    int count = 0;
    queue<Node*> q;
    q.push(root);
    while(count<size){
        Node* temp = q.front();
        q.pop();
        count++;
        if(temp!=NULL){
            q.push(temp->left);
            q.push(temp->right);
        }
    }
    if(q.size()>0){
        Node* temp = q.front();
        if(temp!=NULL) return false;
        q.pop();
    }
    return true;
}
```



```cpp
bool isMax(Node* root){
    if(root==NULL) return true;
    if(root->left!=NULL && root->val<root->left->val) return false;
    if(root->right!=NULL && root->val<root->right->val) return false;
    return isMax(root->left) && isMax(root->right);
}
```

THANK YOU