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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)

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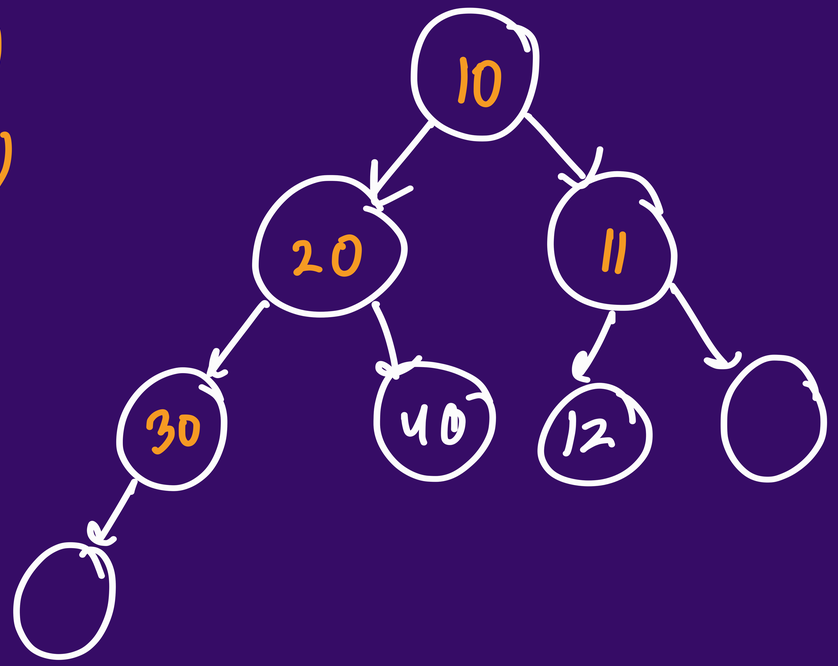
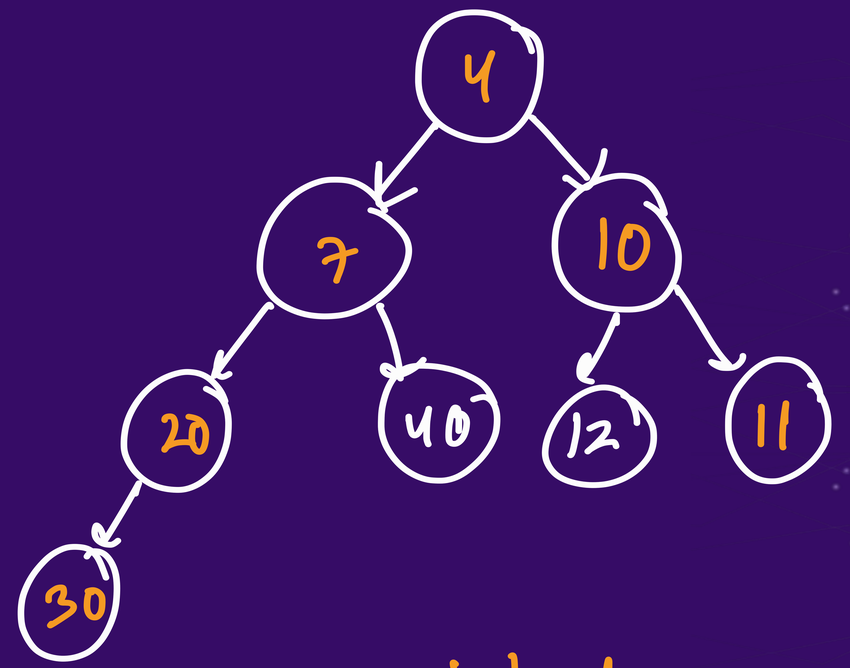
For Ex: Lets do minheap

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

pop()
pop()



minheap



minheap

Heaps Visualisation

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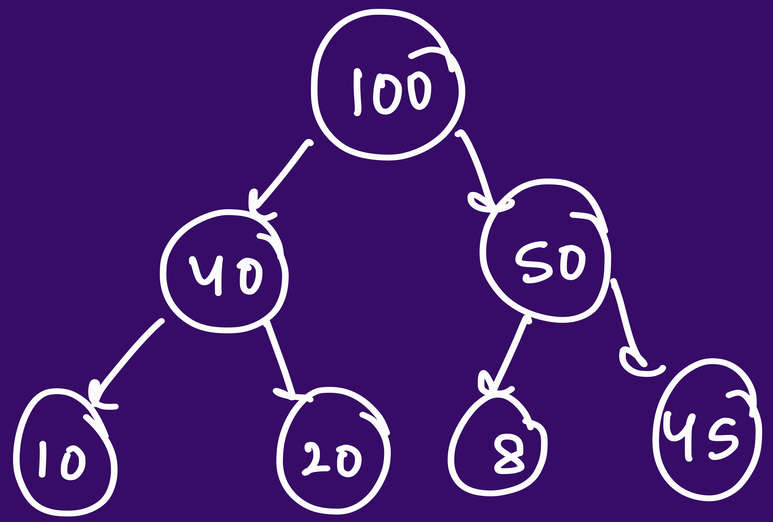
Maxheap



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

Heaps Visualisation

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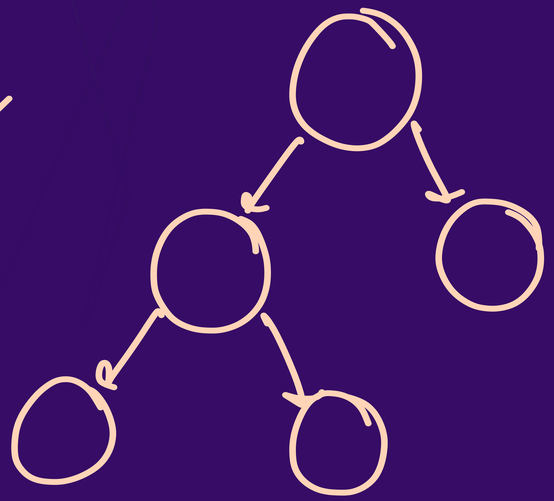
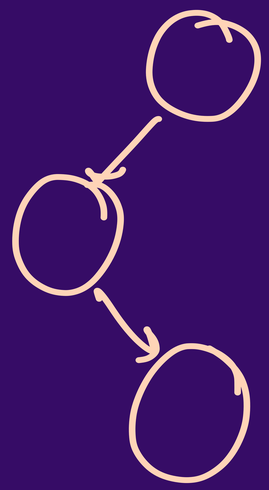
What is a complete Binary Tree ?

CBT ✓

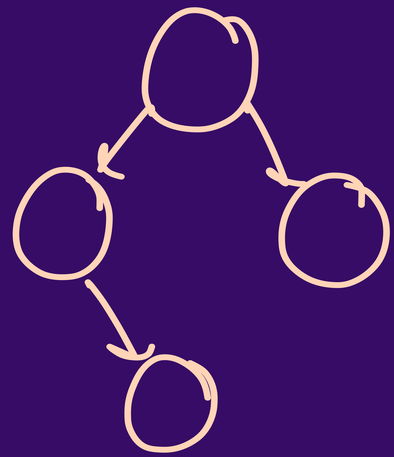


levels = 2

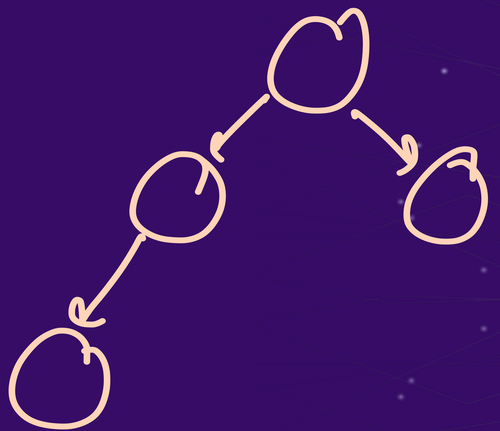


levels = 3

✗



✗



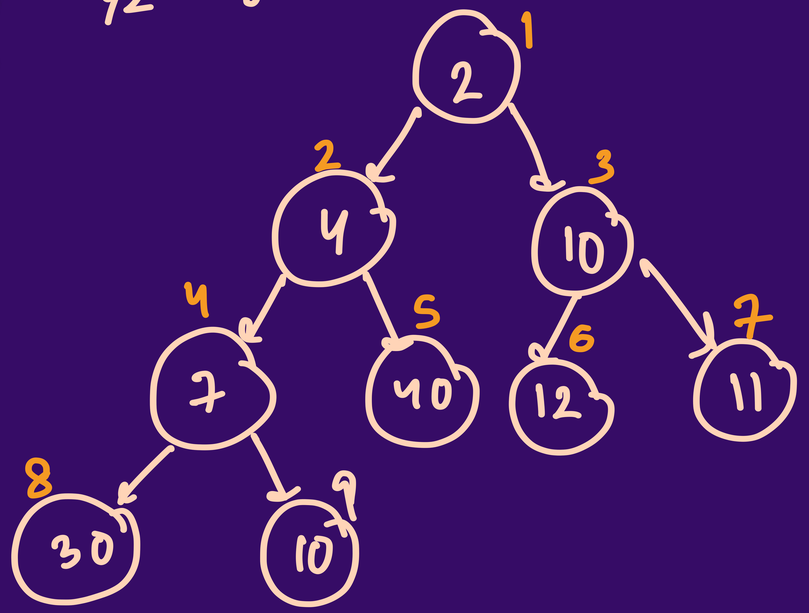
✓

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											

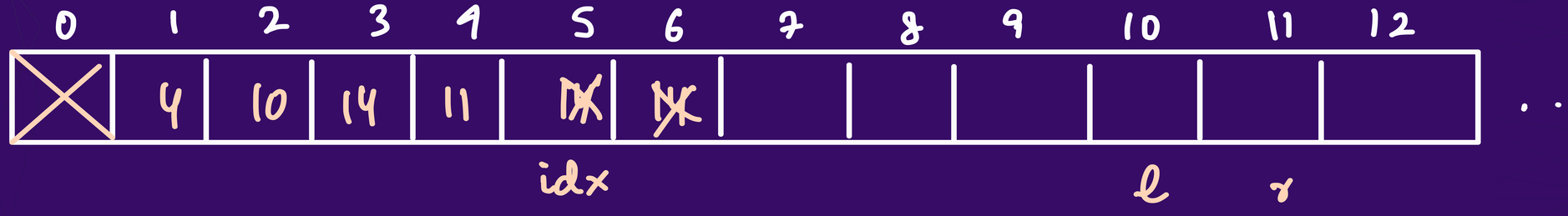


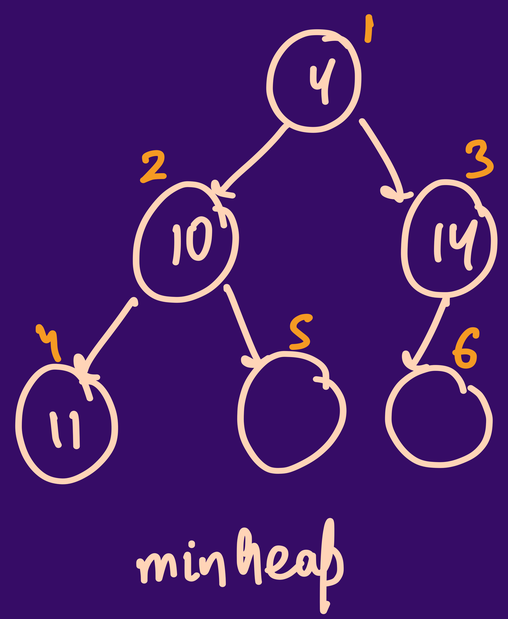
for a node at i,
then,
left child = 2*i
right child = 2*i + 1
parent = i/2

Ques:

Q1 : Implement a MinHeap by Array

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





minheap

Homework :

Implement a MaxHeap using Array

Heapify Algorithm

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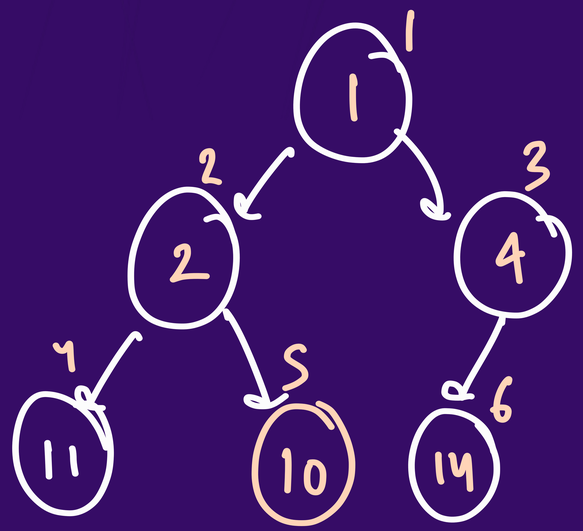
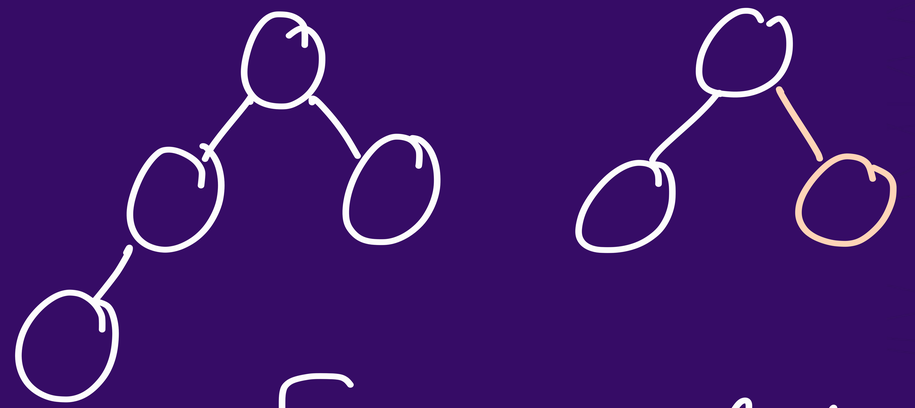
↳ Convert given array to Heap

	1	2	3	4	5	6
arr =	1	2	4	11	10	14

Convert it into minheap





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

even odd

Heapify Algorithm

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```
for (int i = n/2 ; i>=1 ; i--){
    heapify (i, arr, n);
}
```

3

↓

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)

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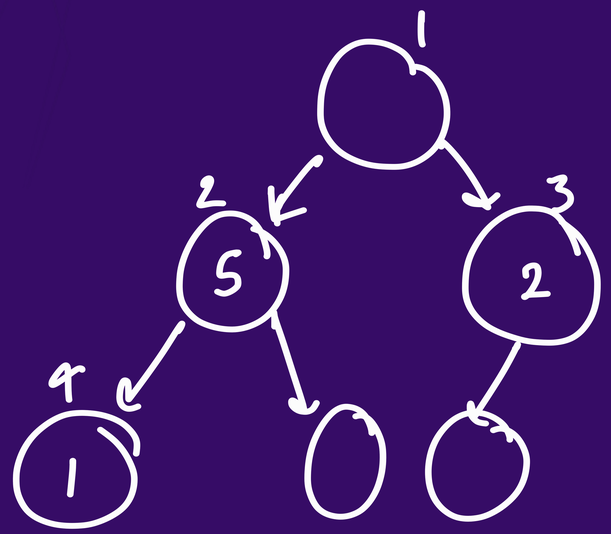
For Ex: an array is given, sort it using heap.

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

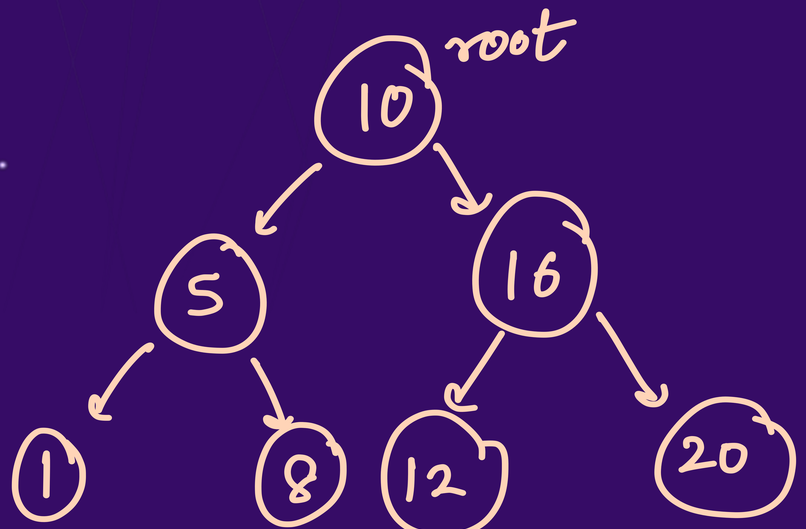
S.C. = $O(n)$

Ques:

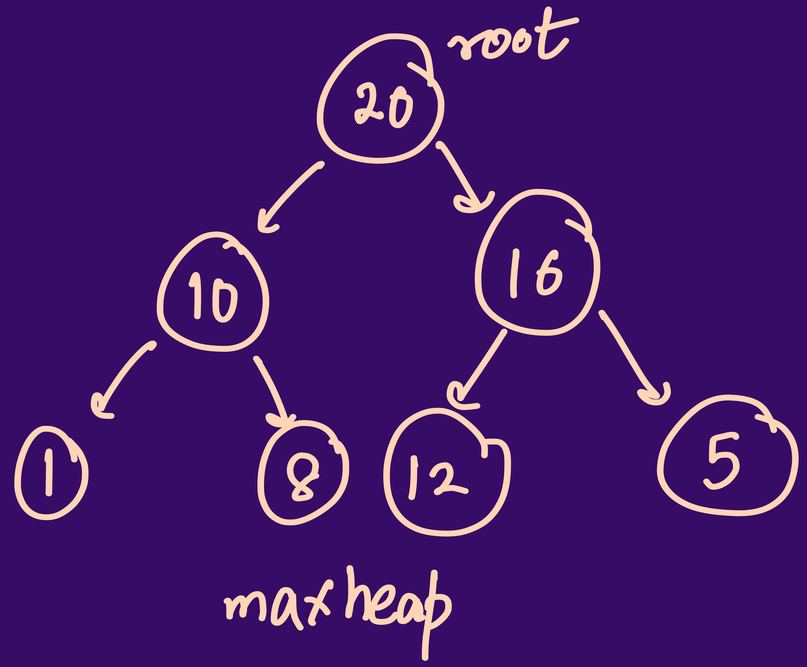
Q2 : Convert BST to MaxHeap

inorder

BST → sorted array



1 5 8 10 12 16 20



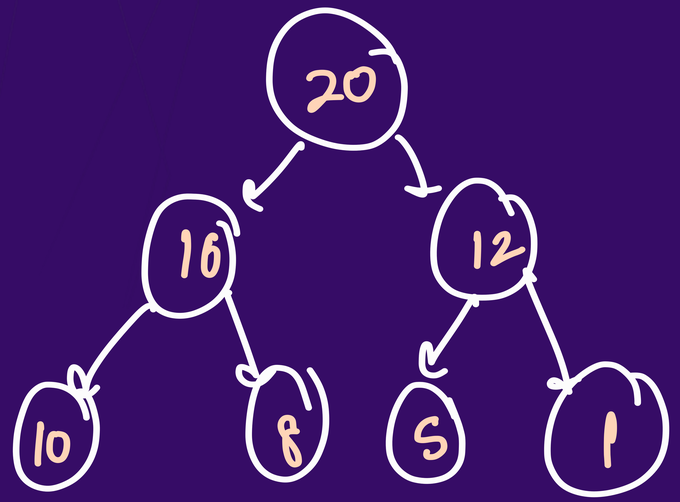
max heap

Ques:

ek LST > RST → O(N-2)

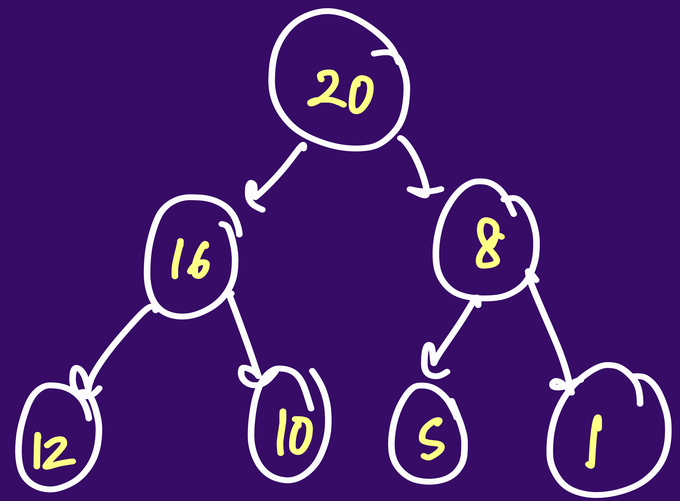
Q2 : Convert BST to MaxHeap

20 16 12 10 8 5 1



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

20 16 12 10 8 5 1



2) Pre Order wise ✓

Ques:

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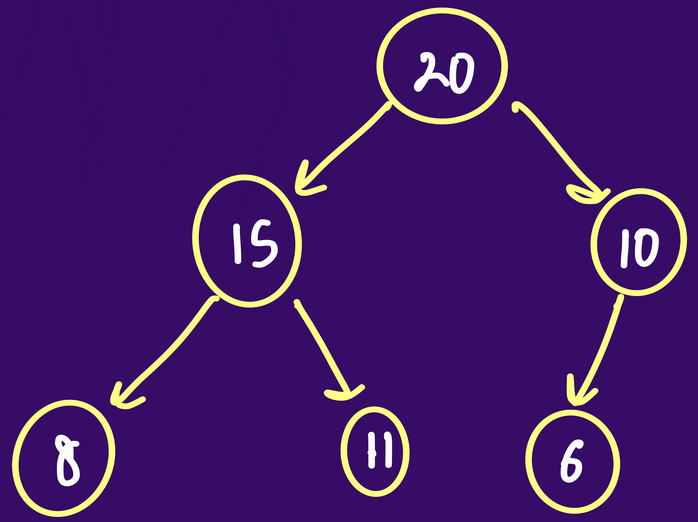
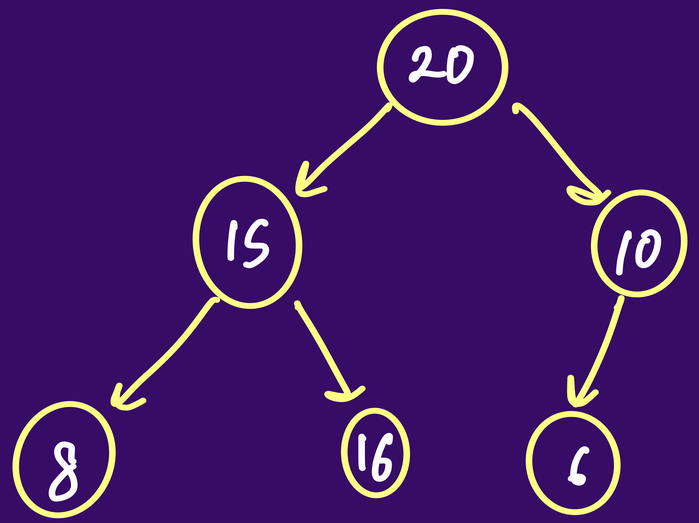
Q3 : Check if given Binary Tree is a MaxHeap or not

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

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



✓



✗

Ques:

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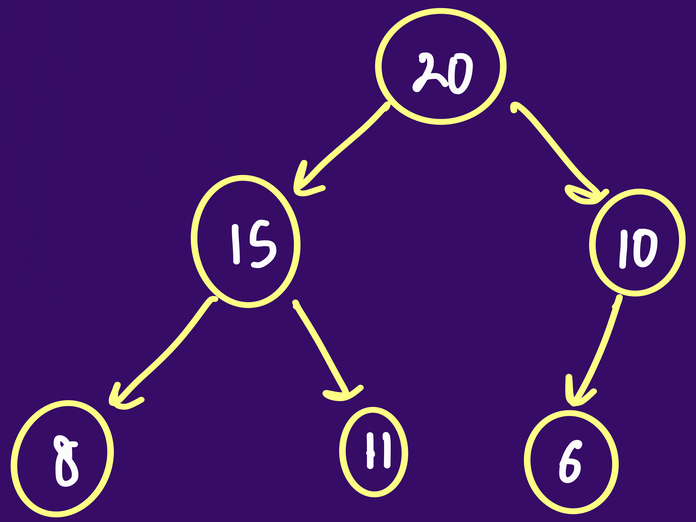
Q3 : Check if given Binary Tree is a MaxHeap or not

Condition-2 : It should be a CBT.



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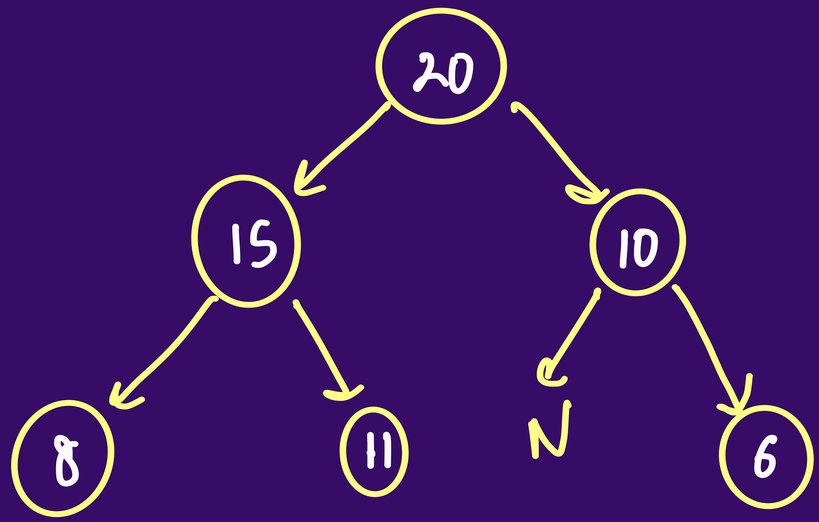
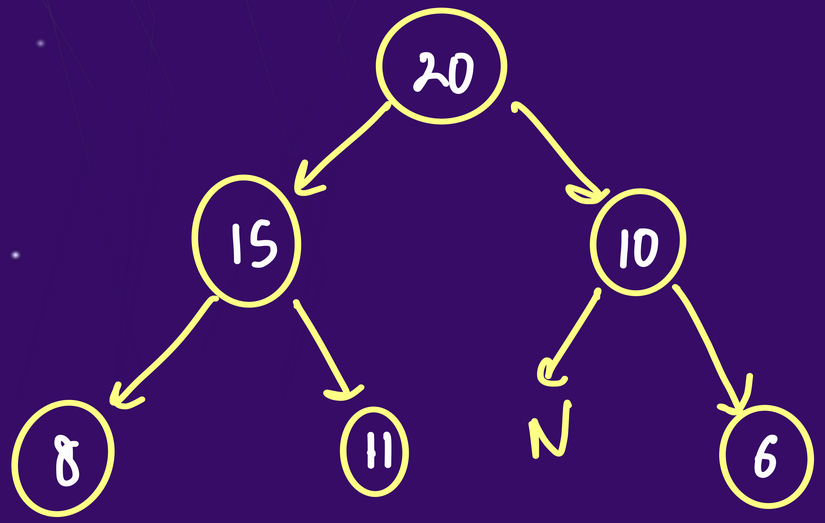


✗

Ques:

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



Size = 6

G N N N N

Q

Count = 0 1 2 3 4 5 6

20 15 10 8 N 11

Ques:

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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