

Striver

Dsa

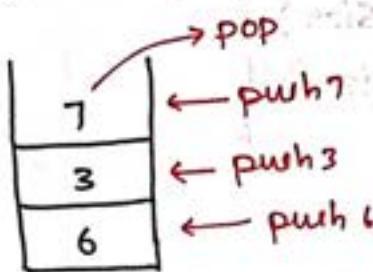
Sheet

"180"

Part - 2

Implement Stack Using Arrays : Problem - 74

push(6)
push(3)
push(7)
top() → 7
pop → pop7
size = 2



```
Size = 1000;
int arr[] = new int [size];
int top = -1; // Initially
void push (int x) {
    top++;
    arr[top] = x;
}
int pop () {
    int x = arr[top];
    top--;
    return x;
}
```

Time complexity - O(N)

Space complexity - O(N)

Implement Queue using arrays : Problem - 75

```
private int arr[];
private int start, end, currsize, maxSize;
public Queue () {
    arr = new int [16];
    start = -1;
    end = -1;
    currsize = 0;
}
```

```
public Queue (int maxSize) {
    this.maxSize = maxSize;
    arr = new int [maxSize];
    start = -1;
    end = -1;
    currsize = 0;
```

```
public void push(int newElement) {  
    if (currSize == maxSize) {  
        mean Queue is full;  
        if (end == -1) {  
            start = 0;  
            end = 0;  
        }  
    }  
    else {  
        end = (end + 1) % maxSize;  
        arr[end] = newElement;  
        currSize++;  
    }  
}
```

```
public int pop() {  
    if (start == -1) {  
        mean Queue Empty  
    }  
    int popeed = arr[start];  
    if (currSize == 1)  
        start = -1;  
    end = -1;  
    else {  
        start = (start + 1) % maxSize;  
        currSize--;  
    }  
    return popeed;  
}
```

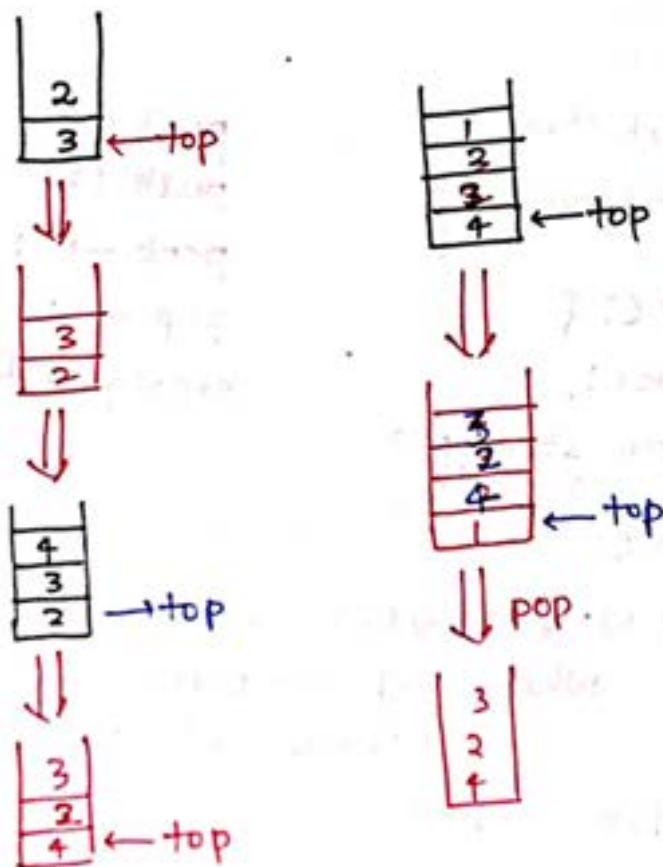
```
public int top() {  
    if (start == -1)  
        mean queue Empty  
    return arr[start];  
}
```

```
public int size() {  
    return currSize;  
}
```

Tc - O(N)

Implement stack using Queue . : Problem - 76

push (3)
 push (2)
 push (4)
 push (1)
 top - ①
 pop - (1)
 top () → ④



after pushing a new element remove all the element from the queue and again put into the queue.

```
Queue<Integer> q;
void push(int x){
    q.add(x);
    for(i=0;i<q.size();i++){
        q.add(q.remove());
    }
}
int pop(){
    return q.remove();
}
int top(){
    return q.peek();
}
int size(){
    return q.size();
}
```

Tc - O(N)
Sc - O(N)

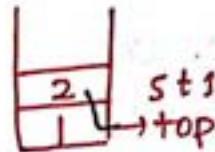
Implement Queue Using Stack : Problem : 77

```

Stack<int> s1();
Stack<int> s2();
public void push(int x) {
    s1.push();
}
public int pop() {
    peek();
    return s2.pop();
}
public int peek() {
    if (s2.isEmpty())
        while (!s1.isEmpty())
            s2.push(s1.pop());
    return s2.peek();
}
public boolean empty() {
    return s2.isEmpty() && s1.isEmpty();
}

```

push(1)
 push(2)
 peek → 1
 pop → 1
 empty → false



SC - $O(2N)$
 TC - $O(N)$

Check for Balance parentheses : Problem : 78

first put all the open brackets into stack and if any closing brackets arrives match with the top of stack and remove. in the last check the size of stack == 0 && it is balance otherwise no.

SC - $O(N)$
 TC - $O(N)$

Next Greater Element : Problem - 79

$N = 4$, $\text{arr}[] = [1, 3, 2, 4]$
output $[3, 4, 4, -1]$

traverse the array from last to 0^{th} index.

```
Stack<int> st();
long nge[] = new int[n];
for(i = arr.length-1; i >= 0; i--) {
    if(!st.isEmpty()) {
        while(!st.isEmpty() && st.peek() <= arr[i])
            st.pop();
    }
    if(st.isEmpty())
        nge[i] = -1;
    else
        nge[i] = st.peek();
    st.push(arr[i]);
}
```

Sc - $O(N)$

Tc - $O(N)$

this is the optimal Approach.

In Brute just select a number and then find the greater number than the selected number if you get then push in the array. otherwise push -1.

Time complexity - $O(N^2)$.

[1, 3, 2, 4]			
nge	3	4	-1

3
2
4

initially stack size = 0

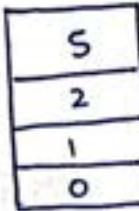
$3 > 2$ (false) remove 2

Sort a Stack :- Problem - 80

Input :



→
sorting



point = 5, 2, 1, 0

main (stack<int> s) { → fun name - sortStack

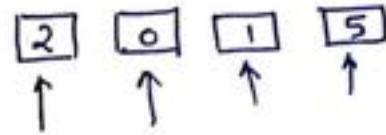
if (!s.isEmpty()) {

int x = s.pop();

sortStack (s);

sortedInsert (s, x);

}



sortedInsert (stack<int> s, int x) {

// if stack is Empty or st.peek is less than x)

// push that element.

if (st.isEmpty() || x > s.peek()) {

s.push (x);

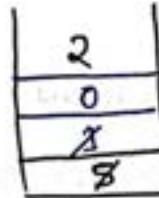
return;

}

int temp = s.pop();

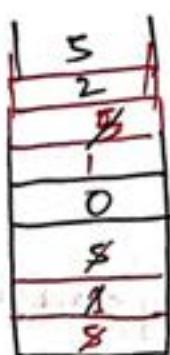
sortedInsert (s, x);

s.push (temp);



temp = 5

temp = 1



⇒



temp = 5
temp = 1

temp = 5
temp = 1

Hypothesis

- ① Pop element
- ② call the function (himself)
- ③ Sorted insert fun (s, x)

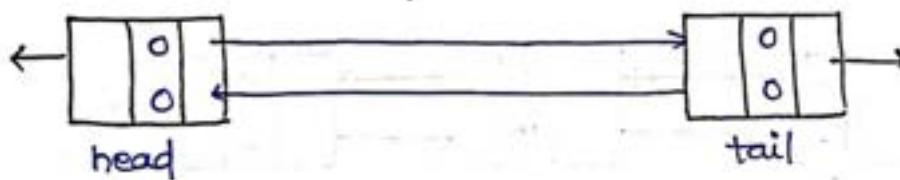
LRU cache - Problem - 82

- LRU Cache (int capacity) - we need to initialize the LRU cache with positive size capacity.
- int get (int key) - return the val of key if the key exists otherwise return -1;
- void put (int key, int value) - Update the val. of key if key exists. otherwise, add the key-val pair to cache. if no of keys exceeds the capacity from this operation, evict the least record.

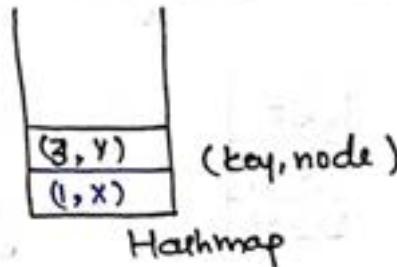
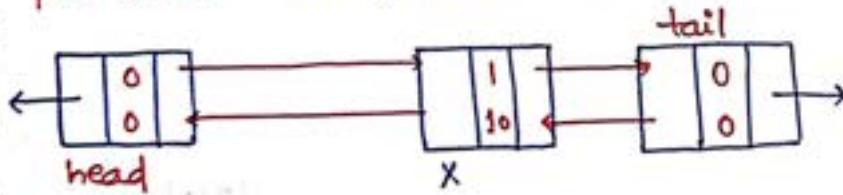
Intuition - While inserting {key, val} pair into DLL make sure that we are inserting it from the back tail to head.

Size = 3 put(1, 10) put(3, 15) put(2, 12) get(3) put(4, 25)

Create a DLL and map.



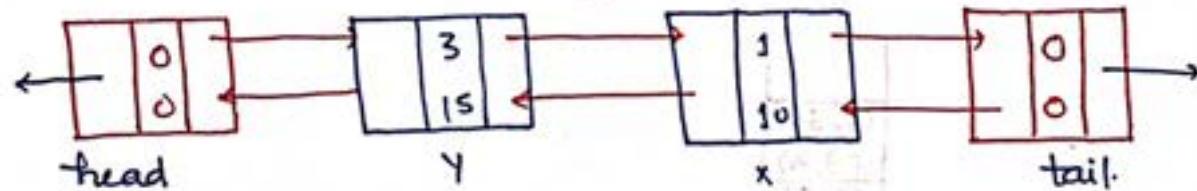
put(1, 10) Not present so put



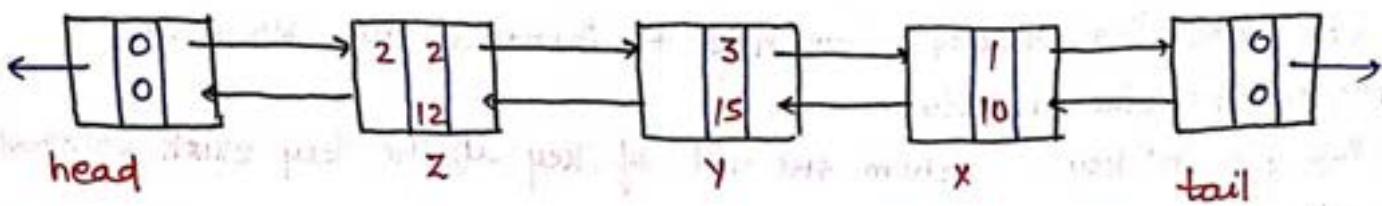
while inserting consider:

- ① check if {key, val} is already present
- ② Check for capacity if capacity == size
so remove the pair which is just right after head node.
and add
- ③ if key is not present return -1

put(3, 15) Not present so put



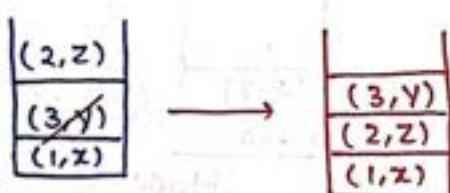
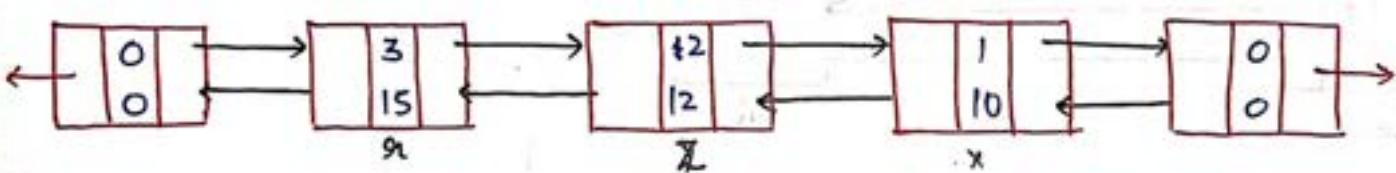
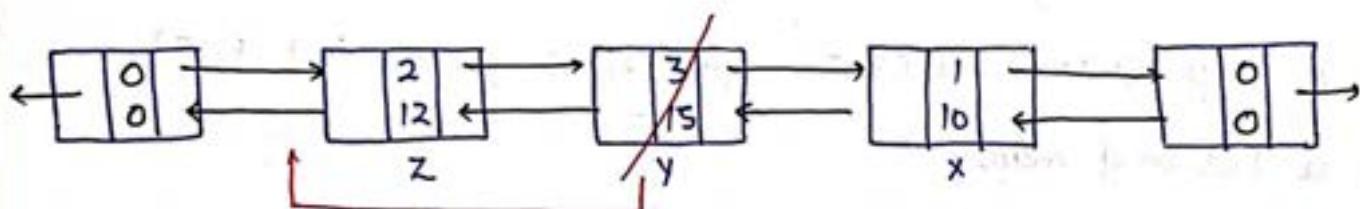
put (2, 12) Not present so put.



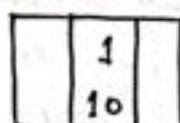
get(3), yes, so it is present.

Now most recent element should be change.

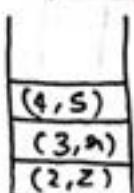
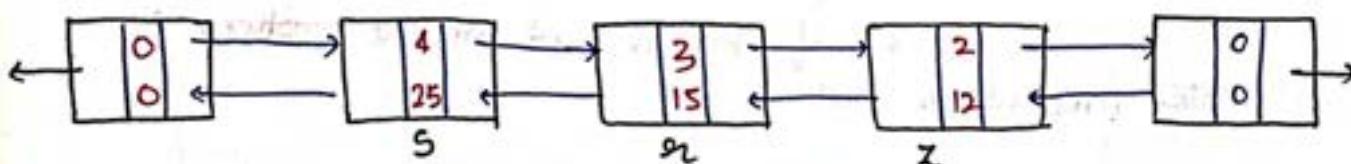
Delete the Node and add it right after head node.



put (4, 25) because capacity full. so we have to remove ^{least} recent used element.



will remove. and add (4, 25)



```
class LRUCache {  
    Node head = new Node (0,0);  
    Node tail = new Node (0,0);  
    Map < int, Node > map = new HashMap ();  
    int capacity ;  
    public LRUCache (int - capacity) {  
        capacity = - capacity;  
        head . next = tail ;  
        tail . prev = head ;  
    }  
  
    class Node {  
        Node prev, next ;  
        int key , val ;  
        Node (int - key , int - value) {  
            key = - key ;  
            value = - value ;  
        }  
    }  
  
    public int get (int key) {  
        if (map . containsKey (key)) {  
            Node node = map . get (key);  
            remove (node);  
            insert (node);  
            return node . value ;  
        }  
        else return -1 ;  
    }  
  
    public void put (int key, int val) {  
        if (map . containsKey (key)) {  
            remove (map . get (key));  
        }  
        if (map . size == capacity) {  
            remove (tail . prev);  
        }  
        insert (new Node (key, val));  
    }  
}
```

```

private void remove (Node node) {
    map.remove (node.key);
    node.prev.next = node.next;
    node.next.prev = node.prev;
}

```

```

private void insert (Node node) {
    map.put (node.key, value) node;
    node.next = head.next;
    node.next.prev = node;
    head.next = node;
    node.prev = head;
}

```

Time complexity - $O(N)$

Space complexity - $O(1)$

LFU Cache (Least frequent used) : Problem 83

get(key) → get the value of key if exists, else -1

put(key, val) → update the value of key if it is present, or insert the key if not present.

when the cache is full, it removes the LFU one if there are multiple LFU so we choose with the help of LRU.

Size = 2

put (1, 10)

put (2, 20)

get (1) → 10

put (3, 30)

get (2) → -1

get (3) → 30

put (4, 4)

get (1) → -1

get (3) → 30

get (4) → 4

freq.

① → (1, 10) (2, 20)

2 → (1, 10)

Now cache is full and remove
(2, 20)

1 → (3, 30)

2 → (1, 10) (3, 30)

because here is a tie so we
remove one of them by taking help
of LRU.

1 → (4, 4)

2 → (4, 4) (3, 30) (4, 4)

3 → (3, 30)

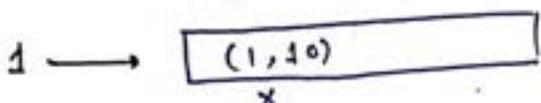
→ DLL

```

Map<freq, list> freqList;
Map<key, nodes> keyNode;
capacity = 0
freq = 0
    
```

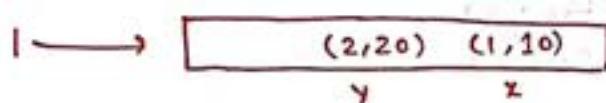
3	2	1
		size = 3
(3, 2)	(2, 4)	(1, x)
		(key, node)

put(1, 10), check that (1, 10) is present in the keynode map or not
if it is not then check for the capacity.



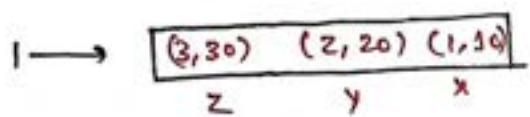
freq = 1
capacity = 1

Now put (2, 20) → verify it is present in the map or not also check the capacity.



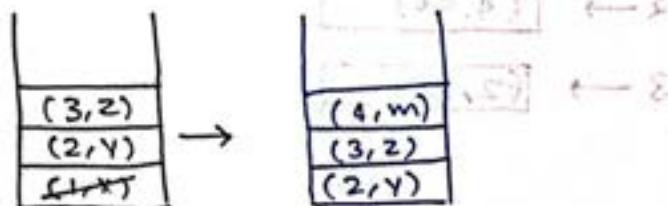
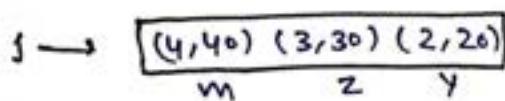
freq = 1
capacity = 2

put (3, 30). → verify is present in the map or not.



freq = 1
capacity = 3.

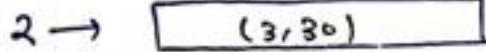
put (4, 40) → it is not present in the map but capacity is full
so we have to remove, so we remove LFU element. but
because it has three elements so choose according to LRU.



(get(z)) → yes it is in the map.

and check for the value of z. it is 30.

and now we have to delete the z node. frequency will be 2.



get(2) → yes it is exist.
the value return. 20

and after that we have to remove the value (2, 20)
and put it into freq[2].

1 → (4, 40)

2 → (2, 20) (3, 30)

get(4) → it is exist. val = 40

1 →

2 → (4, 40) (2, 20) (3, 30)

freq[1] has a empty list
so we have to increase the
freq. freq = 2
Size = 3

put(5, 50) → No we can insert
it, but capacity is full.

1 → (5, 50)

2 → (4, 40)(2, 20)

(4, W)
(5, X)
2, Y

freq = 1

put(2, 25) → 2 is exist so we update it and change
freq.

1 → (5, 50)

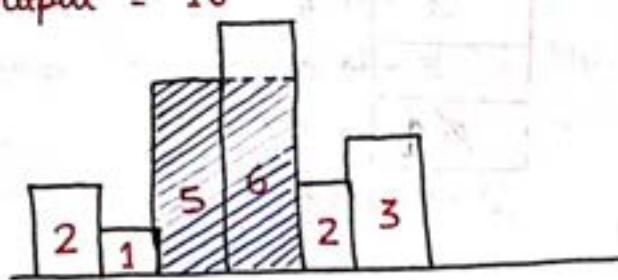
2 → (4, 40)

3 → (2, 25)

Largest Rectangle in a histogram - Problem - 04

Input \Rightarrow heights = [2, 1, 5, 6, 2, 3]

Output = 10



Total rectangle len = 10, width of each flight = 1



Brute-force approach

find the right smaller and left smaller element and find the largest rectangle area of the Histogram.

main (arr, n) {

 int maxArea = 0;

 for (i = 0; i < n; i++) {

 int minHeight = INT-MAX;

 for (j = i; j < n; j++) {

 minHeight = Math.min (minHeight, arr[j]);

 maxArea = Math.max (maxArea, minHeight * (j - i + 1));

}

}

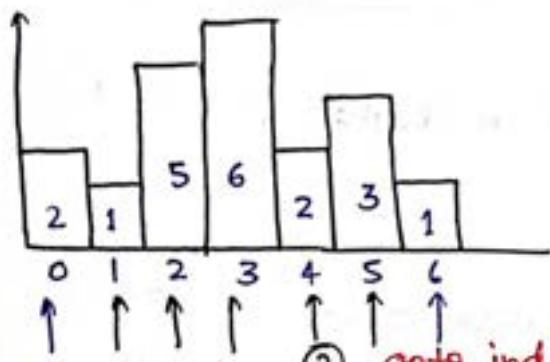
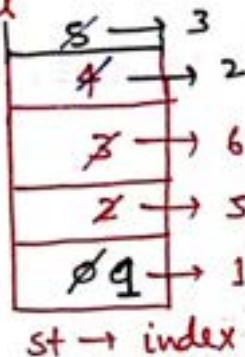
}

Time complexity - $O(N^2)$

Optimised Approach: The intuition behind the approach is the same as finding the smaller element on the both side but in an optimised way using the concept of next greater element & next smaller element.

0	0	2	3	2	5	0
0	1	2	3	4	5	6

left smaller



- ① check $st.\text{peek} > arr[0]$ (No, so put the index)

- ② goto index - 1 and

Now $st.\text{peek} > arr[1]$ (No)
and put the idx into stack.

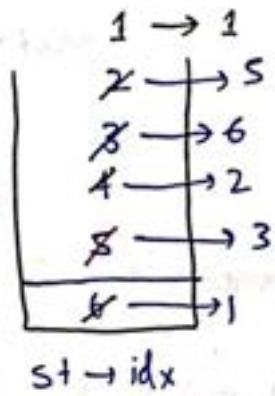
$st.\text{peek} > arr[1]$ (Yes, so remove the element and put the current idx.)

- ④ goto index → 4

$st.\text{peek} > arr[4]$ (Yes) remove 3, 2 from stack
because they both are greater

right smaller -

0	6	3	3	5	5	6
0	1	2	3	4	5	6



- ① On idx - 6
 st is empty put the curr idx in the array. and put 6 inst.

- ② On idx - 5

$st.\text{peek} > arr[5]$, No
put the idx into stack and store the idx in the array.

- ③ No when we go to idx 4 val 2.

$arr[st.\text{peek}] > arr[4]$ Yes, so we have to remove the value from st . and put the idx in arr

and stack.

Now 6 is the boundary so put $6-1=5$ in the arr.

because 6th idx is smaller.

Now st.peek > arr[3] No so put it into st and arr

Now
go to 2

st.peek > arr[2], yes so remove the 3 from stack.

Now after this for $idx-1$ st will empty so put the last idx.

for 0th index -

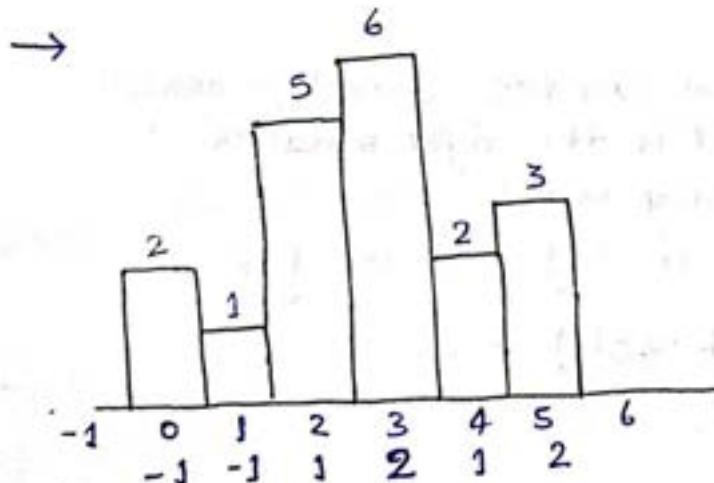
$$\frac{(\text{right smaller} - \text{left smaller}) * a[i]}{\text{idx}}$$

$$Tc = O(N) + O(N) \approx O(N)$$

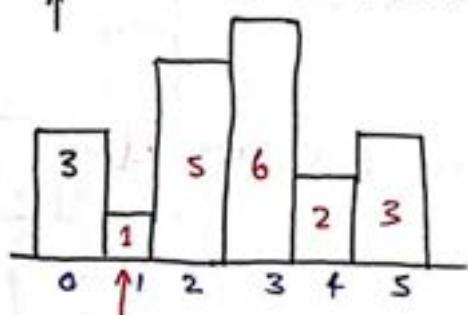
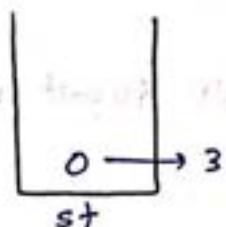
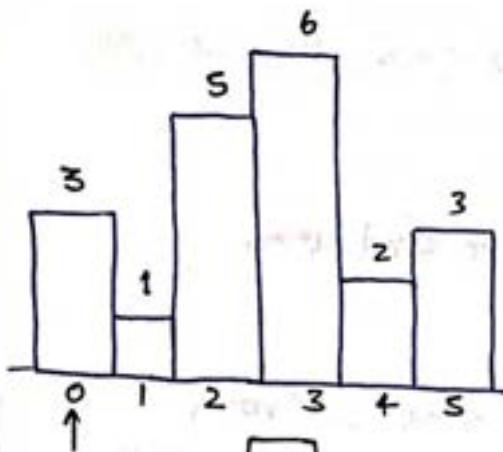
$$Sc = O(3N)$$

Optimised solution - 2

→ pop → bigger or same value
→ arr → push self idx.



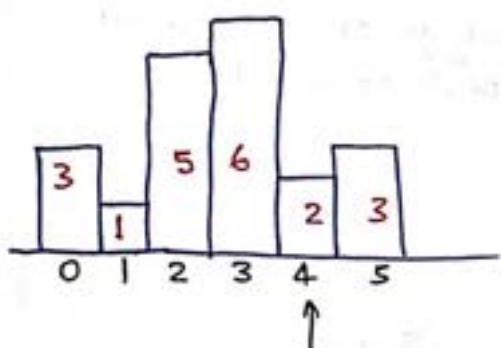
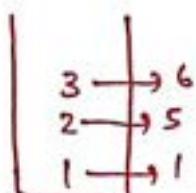
5 → 3
4 → 2
3 → 6
2 → 5
1 → 1
0 → 6
-1 → 2



current val is greater than st.peek
so pop it from st and put the curr idx.

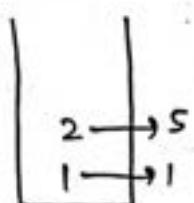


idx 2 and 3 val is greater than arr[st.peek] so simply put it into st



Now we can see $st.peek > arr[i]$
mean it is the right smaller.
so popping out 6 from the st.
and 5 is left smaller for 6.

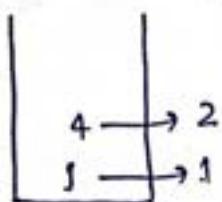
$$\text{MaxArea} = \text{Max}(\text{MaxArea}, (6 * (4 - 2 - 1))) = 6$$



again $st.peek > arr[i]$

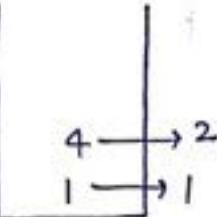
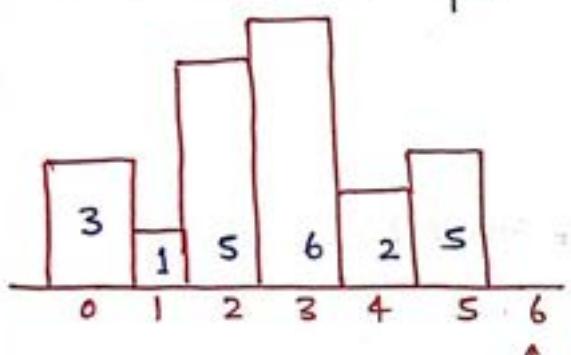
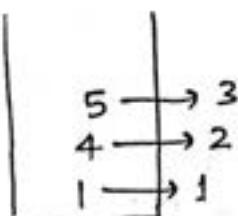
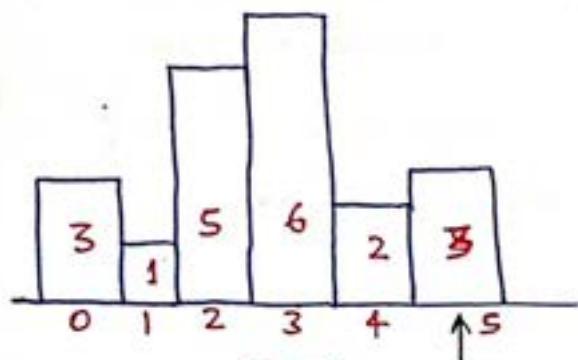
Since 2 is smaller than 5 so it means it means it is right smaller and popping out 5 from the stack , 1 is left smaller for 5

$$\text{MaxArea} = \max(6, (5 * (4 - 1 - 1))) = 10$$



Now 1 is smaller than 2 so we directly

push 2.

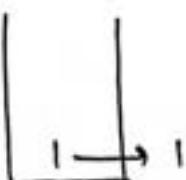


Now we will do one more iteration and consider 6 as a right smaller and so pop out 3 and consider 2 as left smaller.

$$\text{MaxArea} = (10, (3 * (6 - 4 - 1))) = 40$$

consider 6 is right smaller for 4 so pop 4 and 1 is left smaller.

$$\text{MaxArea} = 2 * (6 - 1 - 1) = 8, \quad \underline{\text{MaxArea} = 10}$$



Now pop out 1 6 is the right smaller and 0 is the left smaller.

$$\text{MaxArea} = (50, 1 * (6 - 0 - 1)) = 10$$

```
main(ARR){  
    Stack<int> st;  
    int MaxA = 0;  
    for(i=0; i < n; i++) {  
        while(!st.isEmpty && (i == n || arr[st.peek()] >= arr[i])) {  
            int height = arr[st.peek()];  
            st.pop();  
            int width;  
            if(st.isEmpty()) {  
                width = i;  
            }  
            else {  
                width = i - st.peek() - 1;  
            }  
            maxA = Math.max(maxA, width * height);  
        }  
        st.push(i);  
    }  
    return MaxA;  
}
```

Time complexity - $O(N) + O(N)$
Space - $O(N)$

Sliding window Maximum : Problem - 05

we use the intuition of NGE here.

main (arr) {

Stack < int > st();

int [] nge [] = new int [arr.length];

st.push (arr.length - 1);

nge [arr.length - 1] = arr.length;

for (i = arr.length - 2; i >= 0; i--) {

while (st.size() > 0 && arr[i] >= arr [st.peek ()]) {

st.pop();

}

if (st.isEmpty ()) {

nge [i] = arr.length;

?

else {

nge [i] = st.peek ();

?

st.push (i);

?

for (i = 0; i < arr.length - k; i++) {

int j = i;

while (nge [j] < i + k) {

j = nge [j];

?

print (arr [j]);

}

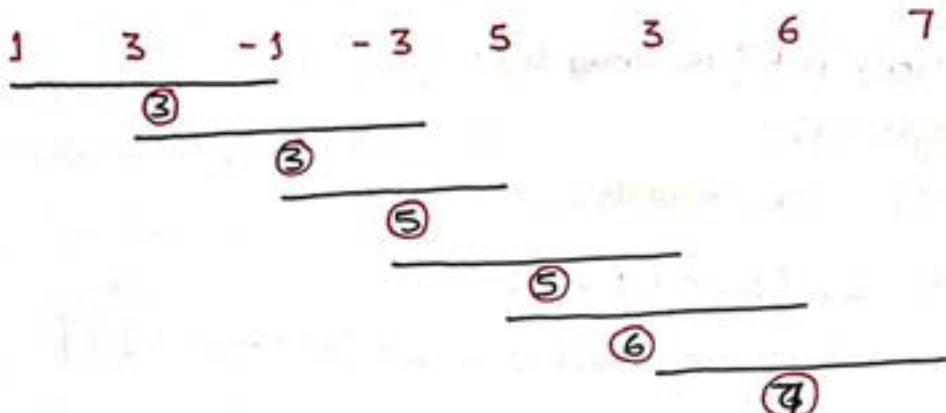
Time complexity - O(N) + O(N)

Space complexity - O(2N).

Approach-2

nums = [1, 3, -1, -3, 5, 3, 6, 7], k = 3

Output = [3, 3, 5, 5, 6, 7]



Naive solution - traverse from 0 to five $s \ (n-k)$ so we can get the max in the every window.

Now firstly traverse from 0 to 2 and find the max from it and put into the array.

```

for (i = 0 → s) {
    maxi = arr[i];
    for (j = i + k - 1) {
        maxi = max (arr[j], maxi)
    }
}

```

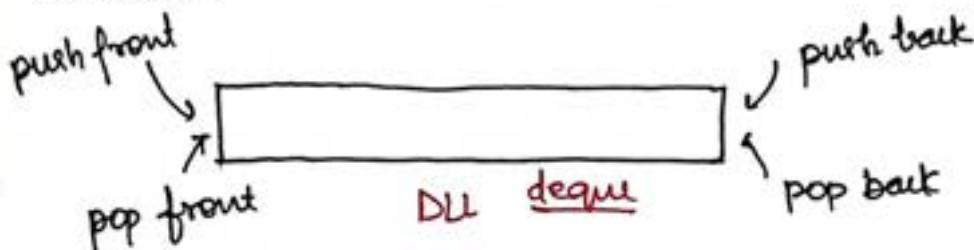
Time complexity - $O(N^2)$

Space - $O(1)$

Optimised Approach

We use the concept of NGE but over here we store the elements in decreasing order. ↓ so we need a deque.

It allows



1	3	-1	-3	5	3	6	7
idx	0	1	2	3	4	5	6
	↑	↑	↑	↑	↑		

In the 0th idx chck does the deque has any thing → No. So push back the val 0

0		
---	--	--

then go to idx 1.

so now compare that peek element of dq, which is 1 is less than 3.

$1 < 3$ which can be my

answer.

take this 0 out after this dq be empty so push 1 into dq.

∅	1	
---	---	--

Move to the 2nd idx. with val -1

Now dq.peek > arr[i] so no need to pop because we are maintaining the decreasing order

∅	1	2
---	---	---

Now we can see 2 is the last index of the subarray of size K.

So, if i look from the front the max element will be on the front.

Now pointer will move on to 3rd idx and if we check arr[dq.peek] > arr[i] so we can push into dq maintain the decreasing order.

1	2	3
---	---	---

3		
---	--	--

ans

of size 3.

Now we have one more subarray

3	3	
---	---	--

ans

Now move to the 4th idx.

0	1	2	3	4	5	6	7
1	3	-1	-3	5	3	6	7

Now my boundary is 2 to 4 but
dq contains 3 so we have to pop 1.

3	3	
ans.		

Now arr[dq.peek] < arr[i] so we have to
pop 3 from dq.

x	2	3	4
---	---	---	---

this 3 to 5 my boundary
so check is there any idx in the
dq out of the boundary. → No

3	3	5	5	
ans.				

also arr[dq.peek] > arr[i] so push

4	5
---	---

New boundary 4-6 No element in the dq is out of
boundary. but. dq.peek < arr[i] pop both elements.

4	5	6
---	---	---

3	3	5	5	6	7
---	---	---	---	---	---

Move to 7 and boundary 5-7
everything in the dq. is in the boundary.

but. dq.peek < arr[i] → pop 6.

6	7
---	---

check from front so it 7 and
correspond to 1 so push it into the array.

Time complexity - $O(N) + O(N) \approx O(N)$

Sc - $O(K)$

main (arr, k) {

int $\pi i = 0;$

int arr[] = new int [n-k+1];

Deque<int> dq;

for ($i = 0$; $i < a.length$; $i++$) {

if ($\neg dq.\text{isEmpty}()$ & $dq.\text{peek} == i - k$) {

$dq.\text{poll}();$

// remove numbers
out of range.

// remove smaller numbers in k range as they are useless.

while ($\neg dq.\text{isEmpty}()$ && $arr[dq.\text{peekLast}()] < arr[i]$)
 $dq.\text{pollLast}();$

$dq.\text{offer}(i);$

if ($i >= k - 1$) {

$ans[\pi i + 1] = a[dq.\text{peek}();]$

}

}

return ans;

// any i which is greater than $k - 1$
be the max in the window because
it will be max because we are
storing everything in decreasing
order.

Implement Min Stack :-

push (-2)	getMin()
push (0)	pop()
push (-3)	getMin()

(-2, -2) _____

Bruteforce - The Naive approach is we have to push the pair and val, min element till now on the stack.

(-2, -2), (0, -2), (-3, -3) we push all the elements.

Now $\text{getMin}() = -3$

if pop ∞ st.

(-2, -2), (0, -2)

$Tc - O(1)$

$Sc - O(2N)$

$\text{getMin}() = -2$

Optimal solution -

push (5)

push (3)

initially min Element will be max set

first we push 5 into the stack because it is empty.

5

$\text{minElement} = 5$

Now we have to push 3 so there can arrive two conditions.

$3 \geq \text{minElement}$

\downarrow
current element

$||$
 $3 < \text{minElement}$

\downarrow
if yes

so directly push the cur
val into the stack

so push $2 \times \text{val} - \text{minElement}$
into stack and update the
val.

3 < 5

so -

$2 \times 3 - 5 = 1$ so we have to push 1 into the stack.



It is work like a flag
(Analog)

minElement = 3

Now if pop operation call so we have to check
st.peek < minElement so its means it was a flag
that was pushed by us and its mean the min
element will change after pop operation

st.peek < minElement



minElement = $2 \times \text{minElement} - \text{st.peek}$

Stack<Long> st;
Long min;

public MinStack(){
min = Long.MAX_VALUE;
}

① void push(int val){

Long x = Long.valueOf(val);

if (st.size == 0) st.push(x);

min = x;

else if (val >= min) {

st.push(x);

else {

st.push(2 * x - min);

min = x;

}

}

② void pop(){
if (st.size == 0) return;
Long val = st.pop();
if (val < min){
min = 2 * min - val;

}

③ int top(){

Long val = st.peek();

if (val < min){
return min.intValue();

}

return val.intValue();

}

Rotting Oranges :- Problem - 07

given $\rightarrow m \times n$ Matrix
size

0 \rightarrow represent empty cell
1 \rightarrow fresh orange
2 \rightarrow Rotten orange

Every min any fresh orange that is 4-directionally adjacent to a rotten orange becomes rotten. Return the min no of min to rot all the orange. If impossible $\rightarrow -1$.

(2)	->1	1
0	1	0
0	0	1

min 0

initially 2 is rotten orange

(2)	(2)	->1
(2)	->1	0
0	1	1

min 1

min 2

min 3

(2)	(2)	(2)
(2)	(2)	0
0	1	1



(2)	(2)	(2)
(2)	(2)	0
0	(2)	1



minTime = 4 minutes.

(2)	(2)	(2)
(2)	(2)	0
0	(2)	(2)

min 4

Let's take a example to think the intuition -

0	1	2
0	2	(2)
1	0	2
2	2	(2)

(1,1)
(2,2)
(1,2)
(0,2)
(2,1)
(0,1)
(1,0)

Q

cnt = 2

$$x = 0 + 2 = 2$$

$$y = 1 + 0 = 1$$

$$x = 2 + 0 = 2 \rightarrow x$$

$$y = 0 - 1 = -1$$

$$\begin{aligned} x &= 2 + 1 = 3 \\ y &= 0 + 0 = 0 \end{aligned} \quad]_x$$

$$x = 2 + (-1) = 1$$

$$y = 0 + (0) = 0 \quad \text{because grid}[1][0] == 0 \text{ no change}$$

$$\begin{aligned} x &= 0 + 0 = 0 \\ y &= 2 + 1 = 3 \end{aligned} \quad] x$$

$$\begin{array}{l} x = 0 + 0 = 0 \\ y = 2 - 1 = 1 \end{array} \quad] \checkmark \text{ push } (0, 1) \text{ into } q_1$$

$$\begin{array}{l} x = 0 + 1 = 1 \\ y = 2 + 0 = 2 \end{array} \quad] \quad \text{push}(1, 2) \text{ into } q.$$

$$\begin{aligned} x &= 0 - 1 = -1 \\ y &= 2 + 0 = 2 \end{aligned} \quad] \quad x \leq 0 \quad -1 < 0$$

$$cut = cut + q \cdot size$$

$$= 2 + 3 = 5$$

$$\begin{array}{l} x = 2 + 0 = 2 \\ y = 1 + 1 = 2 \end{array}] \text{ push } (2, 2) \text{ into av.}$$

$$\begin{array}{rcl} x = 2 + 0 & = & 2 \\ y = 1 - 1 & = & 0 \end{array} \quad] \quad x \text{ already vis.}$$

$$\begin{aligned} x &= 2 + (1) = 3 \\ y &= 1 + (0) = 0 \end{aligned} \quad] \quad x$$

$$\begin{aligned}x &= 2 - 1 = 1 \\y &= 3 + 0 = 0\end{aligned}\quad] \quad x \text{ zero}$$

$\text{pop} \rightarrow 0, 1$

$$\begin{array}{l} x = 0 + 0 = 0 \\ y = 1 + 1 = 2 \end{array} \quad] \quad \text{already present}$$

$$\begin{array}{l} x = 0 + 0 = 0 \\ y = 1 - 1 = 0 \end{array} \quad] \quad \text{Empty cell.}$$

$$\begin{array}{l} x = 0 + 1 = 1 \\ y = 0 + 0 = 0 \end{array} \quad] \quad \text{put it } (1, 1) \text{ into q.}$$

Similarly. $(1, 2) \rightarrow$ change pop and all elements will pop so it will take

the
2 min to
cut

main(grid[][]) {

if (grid == null || grid.length == 0) return 0;

int n = grid.length;

int m = grid[0].length;

Queue<int[]> q = new LinkedList<>();

int cut-fresh = 0;

for (i = 0; i < n; i++) {

 for (j = 0; j < m; j++) {

 if (grid[i][j] == 2) {

 q.offer(new int[] {i, j});

}

 if (grid[i][j] == 0) {

 cut-fresh++;

 }

}

} }

```

if (fresh == 0) return 0;
int cntMin = 0, cnt = 0;
int dx[] = {0, 0, 1, -1};
int dy[] = {1, -1, 0, 0};
while (!qv.isEmpty()) {
    int size = qv.size();
    cnt += size;
    for (i = 0; i < size; i++) {
        Pnt[] point = qv.poll();
        for (j = 0; j < 4; j++) {
            int x = point[0] + dx[j];
            int y = point[1] + dy[j];
            if (x < 0 || y < 0 || x >= n || y >= m || grid[x][y] == 0 ||
                grid[x][y] == 2) continue;
            grid[x][y] = 2;
            qv.offer(new int[] {x, y});
        }
    }
    if (qv.size() == 0) cntMin++;
}
return cnt - fresh == cnt ? cntMin : -1;

```

Time complexity - $O(n \times n) * 4$

Space complexity - $O(n \times n)$.

Online Stock Span - Problem - 08

arr:

100	80	60	70	60	75	85
-----	----	----	----	----	----	----

consecutive smaller
or equal

→ Before it.

op:

1	1	1	2	1	4	6
---	---	---	---	---	---	---

like if we are on 75

so check on the right 60, 70, 60 is less than 75
also these are in consecutive order so including 75 it will
be 4.

Nearest greater to left.



this problem is similar to this.

0	1	2	3	4	5	6
100	80	60	70	60	75	85

If we are in the fifth idx ↑ so nearest greater to
its left will be 80 whose idx is 1

so $5 - 1 = \underline{\underline{4}}$ that will be our ans.

- ① Create an array
- ② Create a stack.
- ③ Use the algo of Nearest greater to left.

Time complexity - $O(N)$

Space complexity - $O(2N)$.

Celebrity Problem - Problem - 89

Celebrity

↳ known by everybody

↳ knows nobody

	0	1	2	3	4
0	0	1	1	1	1
1	1	0	0	1	0
2	1	0	0	1	0
3	0	1	0	0	0
4	0	1	0	1	0

so 3 know nobody and 3 is known by everybody so its celebrity.

there can't be two celebrities and also its is possible that no body is celebrity.

3
2
1
0

pop two elements.

2 3

	0	1	2	3
0	x	✓	✓	✓
1	✓	x	✓	x
2	x	x	x	x
3	✓	✓	✓	x

then check 2 is known by 3 , No

and check 3 is known by 2 , No

we will eliminate one of them so, because.

2 is known by 3 so 3 can't be a celebrity

so 2 push into the st.

2
1
0

Now pop 1 and 2

check 1 knows 2 (yes) so it can't be a celebrity.

push 2 into st

2
0

Now pop 0 and 2

0 knows 2 (yes)

but 2 doesn't know 0 so push 2 into the stack, now st.size == 1 so 2 is a celebrity.

main (arr[]) {

Stack<int> st;

for (i=0; i < n; i++) {

st.push(i);

while (st.size() >= 2) {

int i = st.pop();

int j = st.pop();

if (arr[i][j] == 1) {

st.push(j); // if i knows j → i is not a celebrity

else {

st.push(i);

}

} }

int pot = st.pop();

for (i=0; i < n; i++) {

if (i == pot) {

if (arr[i][pot] == 0 || arr[pot][i] == 1)

return -1;

}

}

return pot;

Tc- O(N)

Sc- O(N)

Reverse words in a String : Problem - 90

Input: $s = \text{"The sky is blue"}$

Output: "blue is sky The"

We can follow the Brute-force initially. use a stack.

and if there is a character add it into the string and if there is any space put it into the stack and initialize $\text{str} = ""$ again.

$s += " "$ → Because we want to add the last string as well.

```
Stack < String > st();
String str = "";
for (i=0; i<s.length(); i++) {
    if (s.charAt(i) == ' ') {
        st.push(str);
        str = "";
    }
}
```

```
else {
    str = s.charAt(i);
}
}
```

```
String ans = "";
while (st.size() != 1) { // otherwise it adds a empty ch. in the
    ans = ans + st.pop() + " ";
}
st.pop();
}
```

$ans = ans + st.pop(); \rightarrow$ // finally add the last element in the string.
return ans;

Time complexity - $O(N)$

Space complexity - $O(N)$.

Optimal Approach

- Start traversing the String from the end until we hit a space. It means we have gonna part a word.
- Check if ans variable is empty or not.
- If it's empty, it indicates that it is the last word we need to print.
- If it is not empty we add it to result with a space after it.

main fun(s) {

 int left = 0, right = s.length() - 1;

 String temp = ""; → for storing substring.

 String ans = ""; → for storing final string.

 while (left <= right) {

 char ch = s.charAt(left);

 if (ch != ' ') {

 temp += ch;
 }

 else if (ch == ' ') {

 if (!ans.equals(" ")) {

 ans = temp + " " + ans;

 }

 else {

 ans = temp;

 }

 temp = "";

 }

 left++;

}

Tc - O(N)

Sc - O(1)

// for adding last word

 if (!temp.equals(" ")) {

 if (!ans.equals(" "))

 ans = temp + " " + ans;

 else ans = temp;

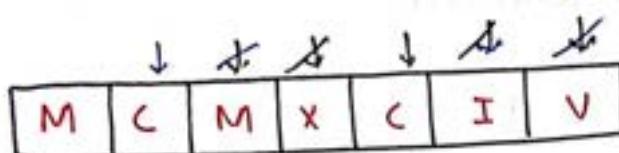
}

return ans;

Roman to Integer : Problem-91

Symbol	Value
I	1
V	5
X	10
L	50
C	100
D	500
M	1000

- I can be placed for V(5) and X(10) to make 4 and 9.
- X can be placed before L(50) and C(100) to make 40 and 90.
- C can be placed before D(500) and M(1000) to make 400 and 900.



- Start traverse from end initially

$$\text{res} = \boxed{V}, 80 \quad \boxed{\text{res} = 5}$$

then go to I

Now currently we are in I which is 1

and res is 5 mean value of (I) < res.

so simply subtract.

$$\text{res} = \text{res} - \text{val of (I)}$$

$$\boxed{\text{res} = 5 - 1 = 4}$$

the goto C -

on val of (C) which is 100 > res. so we have to add it to the result.

$$\begin{aligned}\text{res} &= \text{res} + \text{val of (C)} \\ &= 100 + 4 \\ &= 104\end{aligned}$$

the goto X whose val is 10 so we need to subtract val of (X) < res.

$$\begin{aligned}\text{res} &= \text{res} - \text{val of (X)} \\ &= 104 - 10 \\ &= 94\end{aligned}$$

then goto Mn so res = 1094
then goto C so res = 994

on M res = 1994

```

Map<Character, int> m;
put I, V, X, L, C, D, M with its value manually.

int res = map.get(s.charAt(s.length() - 1));
for (i = s.length() - 2; i >= 0; i++) {
    if (map.get(s.charAt(i)) < map.get(s.charAt(i + 1))) {
        result -= map.get(s.charAt(i));
    } else {
        result += map.get(s.charAt(i));
    }
}
return result;

```

Time complexity - $O(N)$

Space complexity - $O(N)$

String to Integer: Problem 92

atoi algorithm → • read in and ignore leading white space.

- check for +, - if it is met in the last.
- Ignore the non digit character and return the one.
- convert "123" → 123
"0032" → 32.
- 32 bit signed integer range $[-2^{31}, 2^{31} - 1]$. then clamp the integer so it remains in the range.

```

main fun (String s) {
    if (s == null) return 0;
    s = s.trim();
    if (s.length() == 0) return 0;

```

```

int sign = +1;
long ans = 0;
if (s.charAt(0) == '-' ) sign = -1;
int MAX = Integer.MAX-VAL;
int MIN = Integer.MIN;
int i = (s.charAt(0) == '+' || s.charAt(0) == '-') ? 1 : 0;
while (i < s.length()) {
    if (s.charAt(i) == ' ' || !Character.isDigit(s.charAt(i))) break;
    ans = ans * 10 + s.charAt(i) - '0';
    // Check
    if (sign == -1 && -1 * ans < MIN) return MIN;
    if (sign == +1 && ans > MAX) return MAX;
    i++;
}
return (int)(sign * ans);

```

Time complexity - $O(N)$.

Space complexity - $O(1)$.

Longest common prefix - Problem - 93

Str = ["flower", "flow", "flight"]
 O/P = "Fl"

Sort the string and compare the first and last string, so we able to find the common prefix.

Why sorting - ? The reason why we sort the input array and compare first and last strings is that the longest common prefix of all the string must be a prefix of first and last. This is because strings are based on their alphabetical order.

Like if we have -

[flower, flow, apple, flight, food]

Sort - [apple, flower, flow, flight, good]

We can clearly see the max diff between the character is between 1st and last string.

```
main fun( String[] str) {
    Arrays.sort(str);
    String s1 = str[0];
    String s2 = str[str.length - 1];
    int idx = 0;
    while (idx < s1.length() && idx < s2.length()) {
        if (s1.charAt(idx) == s2.charAt(idx)) {
            idx++;
        } else
            break;
    }
    return s1.substring(0, idx);
}
```

Time complexity - $O(N \log N) + O(M)$

Space complexity - $O(1)$

Pattern searching | Rolling hash | Robin Karp - Problem - 94

$a = "abcd"$, $b = "cdabcdab"$

O/p = 3

given two strings a and b , return the min number of times you should repeat string a so that b is substring of a . if impossible $\infty - 1$.

firstly look at Robin Karp:

so we have a given text and pattern we have to check the pattern is a substring of text or not.

text $\rightarrow a \downarrow b \rightarrow x \rightarrow a \rightarrow b \rightarrow c \rightarrow \dots$

pattern $\rightarrow a \rightarrow b \rightarrow c$

Brute force -

Compare the text and pattern character one by one.

① first both matched the character a and a .

② Now move to pointer to next idx.

text $\rightarrow a \downarrow b \rightarrow x \rightarrow a \rightarrow b \rightarrow c$

pattern $\rightarrow a \rightarrow b \rightarrow c$

$\downarrow i$

again b matched with b ., move to the next idx.

text $\rightarrow a \rightarrow b \rightarrow x \rightarrow a \rightarrow b \rightarrow c$

pattern $\rightarrow a \rightarrow b \rightarrow c$

$\downarrow i$ Not matched so rest the pointer i to 0

and set the pointer j to next of previous starting $idx = 1$

text $\rightarrow a \rightarrow b \rightarrow x \rightarrow a \rightarrow b \rightarrow c$

pattern $\rightarrow a \rightarrow b \rightarrow c$

$\downarrow i$

index element not match so move to $j+1$ and $i=0$

Test = $a \rightarrow b \rightarrow x \rightarrow a \rightarrow b \rightarrow c$

pattern = $a \rightarrow b \rightarrow c$

again Not match move the idx. i

test = $a \rightarrow b \rightarrow x \rightarrow a \rightarrow b \rightarrow c$

pattern = $a \rightarrow b \rightarrow c$

① j and i value match so move to next idx

② j and i _____

③ j and i _____

at end $i > \text{pattern.length}$, so it is a substring of test.

Time complexity - $O(m * n)$

Space complexity - $O(1)$.

Optimisation -

test = a b x a b c a b c a b y

pattern = a b c a b y

We want to find the pattern in the given text. It is present or not.

① If at any index the value matches so update the pointer to the next idx. → rule

test = a b x a b c a b c a b y

pattern = a b c a b y

① matched so move to next idx.

② again the values matched. move to next idx.

test = a b $\underset{i}{x}$ a b c a b c a b y
 pattern = a b c a b y
 \uparrow

Not matching the values, so now i keep moving to the left and check that there is any x or not because there is no x so i will set to 0 and j will be increase.

$\downarrow i \downarrow i \downarrow i \downarrow i \downarrow i$
 test = a b x a b c a b c a b y
 pattern = a b c a b y
 $\uparrow i \uparrow i \uparrow x \uparrow i \uparrow i \uparrow i$

- ① Now value matched so move the pointers to next idx.
- ② again matched. move to next idx.
- ③ match ④ match ⑤ match.

Now j is on c and i is on y. \rightarrow No matched so we checked to, mean i keep moving to the left and check there is any c or not.

$\downarrow i$
 test = a b x a b c a b c a b y
 pattern = a b c a b y
 $\uparrow i \uparrow x \uparrow i$

Here we find there is a idx whose value match with j. so put the $i = i+1$ and $j = j+1$

$\downarrow i \downarrow i \downarrow i$
 test = a b x a b c a b c a b y
 pattern = a b c a b y
 $\uparrow i \uparrow i \uparrow i$

- ① matched i and j so move to next idx
- ② matched _____
- ③ matched _____

Now $j > \text{pattern.length}$ mean its true.

Implementation -

text = a b x a b c a b c a b y

pattern = a b c a b y i x i g i t i

\downarrow
a b_i c a b y

0	0	0	1	2	0
---	---	---	---	---	---

till 0 initially

We create a array for setting the longest prefix substring.

① i and j not match move j to next idx

② i and j met match move j to next idx.

③ value of i and j match
so put the val of a_{idx+1}
previous a = 0 + 1 = 1

④ value of i and j
match. → so get the idx → which
is g and add i it it and put

⑤ Now y not match to anyone put 0

$\begin{array}{cccccc} i & x & x & x & x & i \\ \cancel{x} & \cancel{i} & \cancel{i} & \cancel{x} & \cancel{x} & \cancel{i} \\ a & b & c & a & b & y \end{array}$

0	0	0	1	2	0
---	---	---	---	---	---

$\begin{array}{cccccc} i & x & x & x & x & i \\ \cancel{x} & \cancel{i} & \cancel{x} & \cancel{x} & \cancel{i} & \cancel{i} \\ a & b & x & a & b & c \end{array}$

test a b x a b c a b c a b y

Here i and j match - a match

Here _____ - b match

Now x and c are not matching, so

in the array move to the previous location and
look at the val. which having val = 0

so move to idx = 0

Now a compared with x. not equal so update the
 $j = j + 1$ because i is on the first \downarrow
 0^{th} .

Now i and j value match so the idx increment

Now i and j _____

Now y is not matched with c

so we look at the val stored at previous idx. which is 2.

so look at idx 2.

it matches with the c so i and j will be equal/match.

so the whole string matched.

Problem: 95

main fun(s1, s2) {

int n = s2.length;

int lps[] = new int [n];

i=0, j = 1;

while (j < n) {

while (i > 0 && s1.charAt(j) != s2.charAt(i))

i = lps[i-1];

if (s2.charAt(i) == s2.charAt(i))

i++;

lps[j] = i;

j++;

}

i=0, j=0;

while (i < s1.length()) {

while (j > 0 && j < n && s2.charAt(j) != s1.charAt(i))

j = lps[j-1];

if (j < n && s2.charAt(j) == s1.charAt(i))

j++;

i++;

if (i == n) return 1; // mean matched..

7

return -1;

Move on to question:

main (s_1, s_2) {

StringBuilder sb();

int rep = B.length() / A.length();

int = 1;

for (i=0; i < rep+2; i++) {

if (sb.testing().contains(B2))
return ans;

else

res.append(A);

ans++;

}

return -1;

Tc - $O(N) + O(M)$

Sc - $O(N)$.

\Rightarrow Robin Kaup.

Count and Say : Problem - 90

• CountAndSay(1) = "1"

Break the digit into minimal numbers of substrings such that each substring contains exactly one unique digit.

"3322251"

two 3's, three 2's, one 5, one 1

$$= 23 + 32 + 15 + 11$$

= "23321511"

n = 1 "1" one ①

n = 2 "11" two 1x

n = 3 "21" two 1

n = 4 "1211" Start with "1" build n-1

n = 5 "111221" time.

main fun (int n){

String ans = "11"; "1"

if (n == 1) return "1";

if (n == 2) return "11";

for (i = 0; i < n-1; i++) {

ans = build (ans);

}

return ans;

}

// function for ans. build build (ans){

int freq = 1;

char num = charAt(0);

String res = "";

```

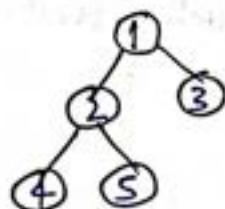
for (i = 1; i < ans.length(); i++) {
    if (curNum == ans[i]: charA(i))
        freq++;
    else
        char freq = (char) ('0' + freq);
        res = res + freq;
        res = res + num;
        curNum = ans[i];
        freq = 1;
}
char freq = (char) ('0' + freq);
res = res + freq;
res = res + num;

```

Morris Inorder Traversal - Problem 104

Inorder - Left, root, right

I/p:



op:

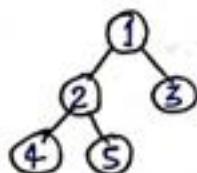
4	2	5	1	3
---	---	---	---	---

```

ArrayList<int> lt;
Stack<Node> st;
Node temp = root.left;
st.push(root);
while (temp != null || !st.isEmpty()) {
    if (temp != null) {
        st.push(temp);
        temp = temp.left;
    } else {
        temp = st.pop();
        lt.add(temp.data);
        temp = temp.right;
    }
}
return lt;
  
```

Pre Order Morris Traversal - Problem - 105

Inorder - Root, left, right



1	2	4	5	3
---	---	---	---	---

```

ArrayList<int> lt;
Stack<Node> st;
st.push(root);
  
```

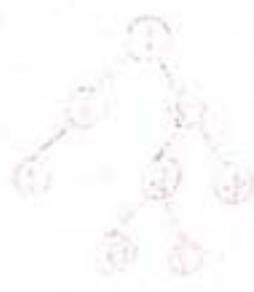
```

while (!st.isEmpty()) {
    Node cur = st.pop();
    lt.add(cur.data);
}
  
```

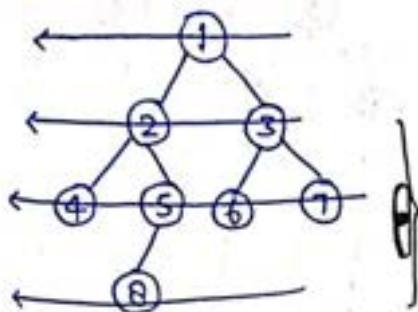
```

        right
if (cur.left != null)
    st.add(cur.left);
if (cur.right != null)
    left st.add(cur.right);
left
return lt;

```



Right/Left View of Binary Tree - Problem - 106



Time complexity - $O(N)$
Space complexity - $O(H)$

Intuition: We have to do a recursive level order traversal.

Root Right Left \rightarrow for Right View

Root Left Right \rightarrow for Left view

public class Solution {

 public List<int> rightSideView (TreeNode root) {

 List<Integer> res = new ArrayList<>();

 helprightsideView (root, result, 0);

 return res;

 } fun helprightsideView { TreeNode cur, List<int> res, int dep) {

 if (curr == null) return;

 if (depth == res.size ())

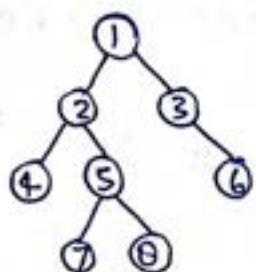
 res.add (curr.val);

 helprightView (curr.right, res, dep+1);

 helprightView (curr.left, res, dep+1);

} swap for left view.

Bottom View of Binary Tree



Bottom View - [4 | 7 | 5 | 8 | 6]

BottomView(root) {

```

        ArrayList<int> res;
        if (root == null) return res;
        Map<int, int> treemap;
        Queue<Node> qv;
        root.hd = 0;
        qv.add(root);
    
```

while (!qv.isEmpty()) {

 Node temp = qv.poll();

 int hd = atemp.hd;

 map.put(hd, temp.data); // for Top view check

 if (temp.left != null)

 temp.left.hd = hd - 1;

 qv.add(temp.left);

 if (temp.right != null)

 temp.right.hd = hd + 1;

 qv.add(temp.right);

}

for (Map.Entry<int, int> entry : map.entrySet()) {

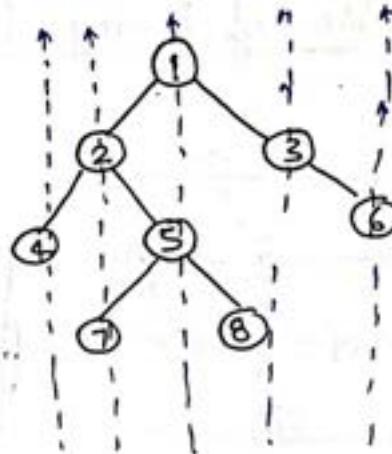
 res.add(entry.getValue());

}

return res;

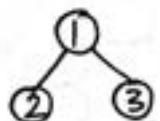
Time complexity - $O(H)$

Space " - $O(N)$

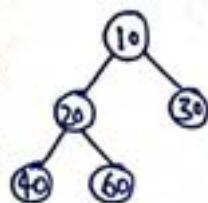


if (map.contains
 (hd) == false)

Root to Leaf Paths



O/p: 1 2 # 1 3



I/p: o/p: 10 20 40 # 10 20 60 # 10 30

ArrayList<ArrayList<int>> one;

ArrayList<int> lt;

main(Node root)

 help(root);

 return one;

help(Node root) {

 if (root == null) return;

 lt.add(root.data);

 if (root.left == null && root.right == null)

 one.add(new ArrayList<>(lt));

 help(root.left);

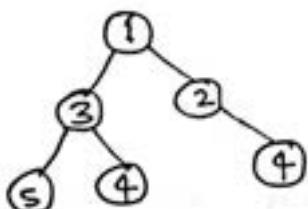
 help(root.right);

}

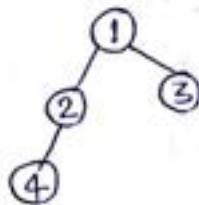
Time complexity - O(N)

Space complexity - O(N)

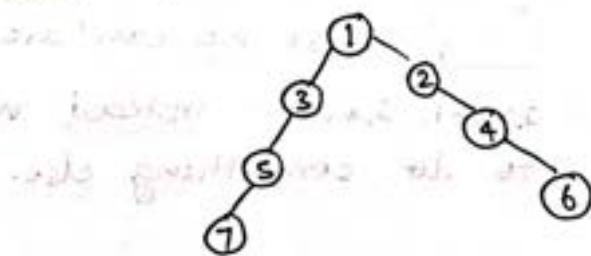
Maximum width of Binary Tree



Max width = 4



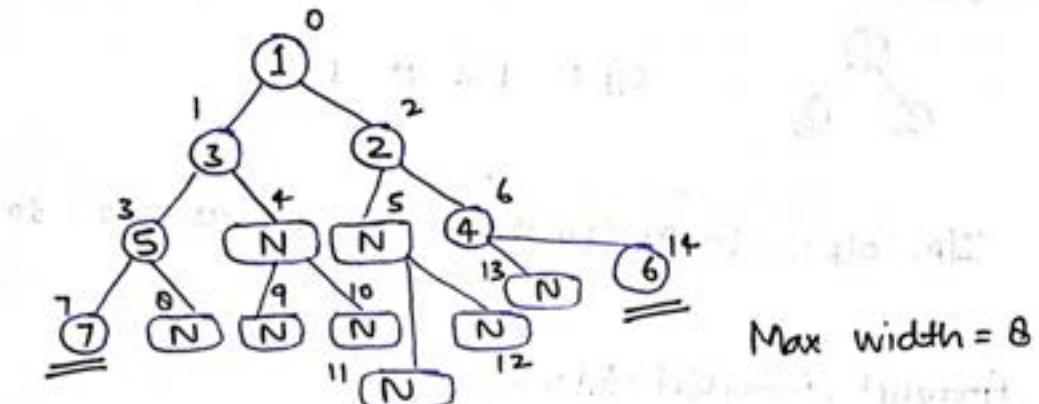
max width = 2



Max width = 8

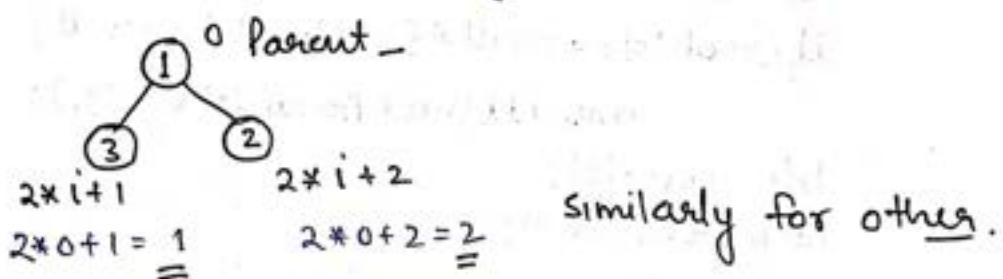
width for a level is defined as the maximum number of nodes between the left most and right most node of level.

Intuition:

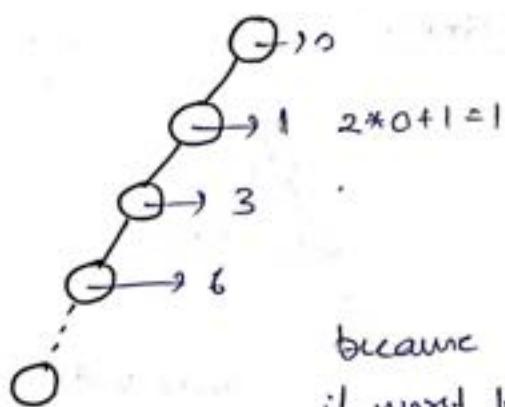


See the left most and right most node at every level : for achieve this we need unique id for every Node. Once we knew the left most and right most nodes width can be decide as $(rightMost - leftmost + 1)$.

A parent given $2 * i + 1$ to left child and $2 * i + 2$ to the right child.

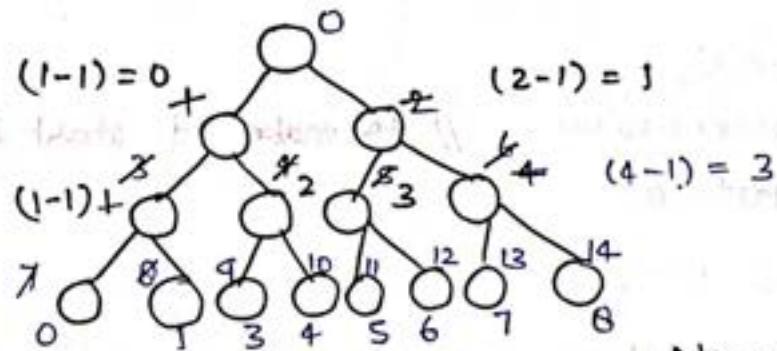


But this fails on tc.



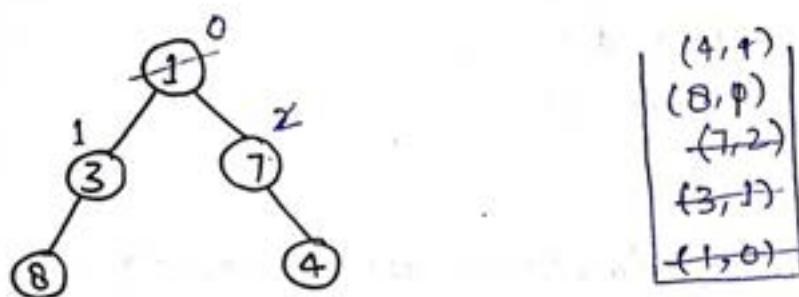
because increasing in twice if worst length 10⁵ so it will overflow. so we can't use exactly $2 * i + 1, 2 * i + 2$. instead we need to do something else.

How to prevent overflow



Now we can see that

we handle the overflow condition.



width = $\sqrt{2}$

$$(3, 1) \rightarrow (1-1) = \underline{\underline{0+1}} = \underline{\underline{1}}$$

(last - first + 1)

$$(7, 2) \rightarrow (2-1) = 1$$

$$(2-1) + 1 = \cancel{2} 4$$

```
class TreeNode {
    int data;
    TreeNode left, right;
    TreeNode (int data) {
        this.data = data;
        left = null;
        right = null;
    }
}
```

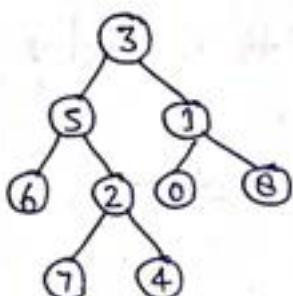
```
main (root) {
    if (root == null) return 0;
    int ans = 0;
    Queue <Pair> q = new LinkedList ();
    q.add (new Pair (root, 0));
```

```
class Pair {
    TreeNode node;
    int num;
    Pair (TreeNode node, int num) {
        this.node = node;
        this.num = num;
    }
}
```

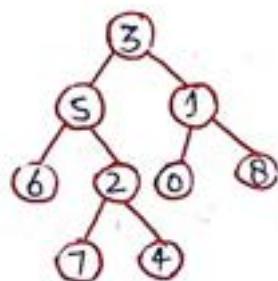
```
while (!q.isEmpty()) {
    int size = q.size();
    int min = q.peek().num; // to make id start from 0.
    int first = 0, last = 0;
    for (i=0; i<size; i++) {
        int cur_id = q.peek().num - min;
        TreeNode node = q.peek().node;
        q.poll();
        if (i==0) first = cur_id;
        if (i==size-1) last = cur_id;
        if (node.left != null)
            q.add(new Pair(node.left, cur_id*2+1));
        if (node.right != null)
            q.add(new Pair(node.right, cur_id*2+2));
    }
    ans = (ans, last-first+1);
    max = max;
}
return ans;
}
```

lowest common Ancestor of a Binary Tree

↓
the lowest parent of two Nodes



$p=5, q=1$, the LCA will be 3



$p=5, q=4$

lowest CA = 5

intuition - we can observe that we can find the LCA of 2 given nodes from

- ① Left subtree or right subtree
- ② If not in both, the root will be LCA.

1. If root is null or if root is x or if root is y then return root.

2. Make a recursion call for both.

① left
② Right

* Make a recursive call → left subtree

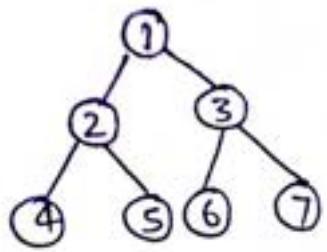


if null, mean LCA not found on left subtree which means we found LCA on right subtree. go return Right.

* Make a recursive call → right subtree



if null, mean LCA not found on right subtree which means we found LCA on left so return left.



$$x = 4, y = 5$$

$\text{root} \neq \text{null}$ & not equal to x and y
so recursion call.

call left subtree if find 4 to this call will return
4 to its parent.

At present the parent is 2.

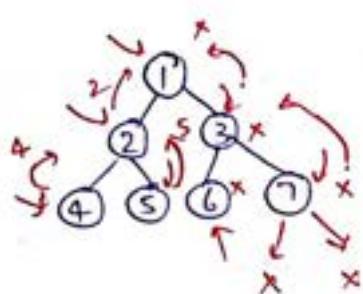
* Call the right subtree, while calling it will find 5.
and this call will return 5 to its parent.

Now left recursive call returns val. not null
&

Right recursive call " " "



thus 2 will return itself to root i.e. to 1.



$$\text{lca}(4, 5) = 2$$

Brute force - take the root to node path to x and y .

$(1, 2, 4)$

$O(N) \rightarrow$ Space

$(1, 2, 5)$

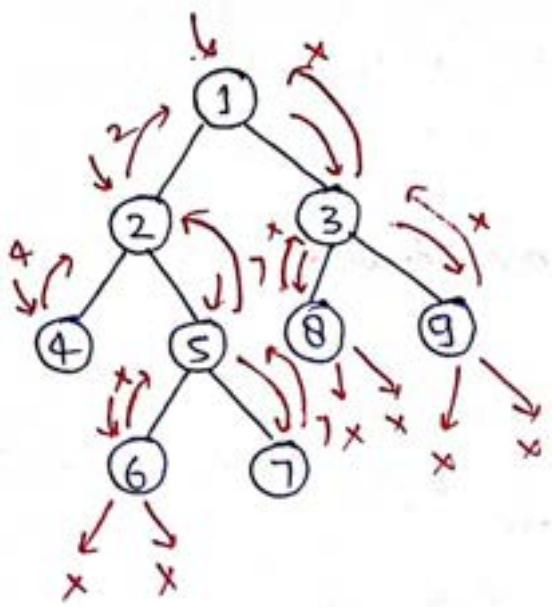
Time

at zeroth idx match

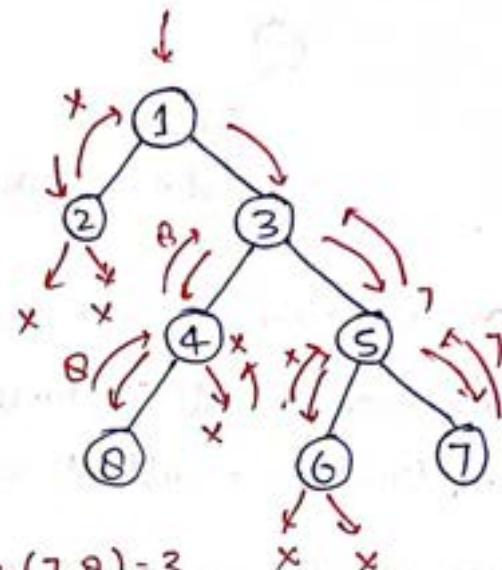
at 1st idx match

not matched on 2nd so

last match was 2 so it is LCA.



$\text{lca}(4, 7) = \underline{2}$



$\text{lca}(7, 8) = \underline{3}$

both the node we got so we
are confirm that this the the
lca we are looking for

main LCA()

```
if (root == null || root == p || root == q) return root;
```

```
TreeNode left = LCA(root.left, p, q);
```

```
TreeNode right = LCA(root.right, p, q);
```

// result

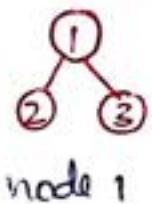
```
if (left == null) return right;
```

```
if (right == null) return left;
```

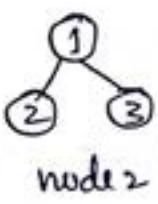
```
else return root; // if left and right both != null we  
found the result.
```

Check if two trees are identical -

1



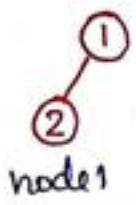
node 1



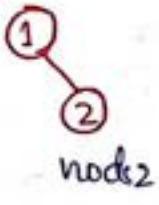
node 2

both are identical.

2



node 1



node 2

not identical.

boolean identical (node1, node2){

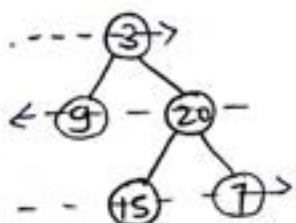
 if (node1 == null && node2 == null) return true;

 if (node1 == null || node2 == null) return false;

 return ((node1.data == node2.data) && identical (node1.left, node2.left) && identical (node1.right, node2.right));

}

Binary Tree Zig Zag level order Traversal.



O/P: [[3], [20, 9], [15, 7]]

main (levelordertraversal (root) {

 List<List<int>> lt;

 if (root == null)

 return lt;

 Stack<Node> st1;

 Stack<Node> st2;

 st1.push (root);

 TreeNode curr;

bodean lter = true;

while (!st1.isEmpty() || !st2.isEmpty()) {

 List<int> level();

 if (lter) {

 while (!st1.isEmpty()) {

 curr = st1.pop();

 lter = curr.add(curr.val);

 level

 if (curr.left != null)

 st2.push(curr.left);

 if (curr.right != null)

 st2.push(curr.right);

}

}

 else {

 while (!st2.isEmpty()) {

 curr = st2.pop();

 level

 lter = curr.add(curr.val);

 if (curr.right != null) st1.push(curr.right);

 if (curr.left != null) st1.push(curr.left);

}

}

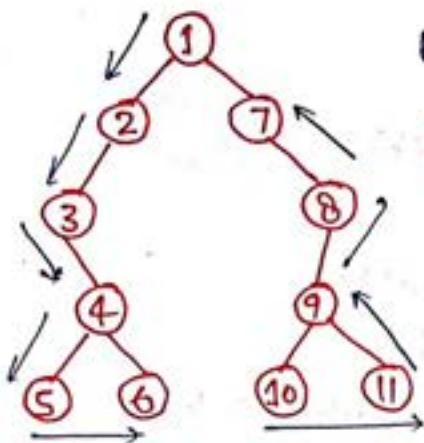
 ans.add(lter);

 lter = !lter;

return ans;

}

Boundary Traversal of Binary Tree.



Boundary traversal:

1	2	3	4	5	6	10	11	9	8	7
---	---	---	---	---	---	----	----	---	---	---

- Part 1: Left Boundary of tree.
- Part 2: All the leaf nodes travelled in the left to right
- Part 3: Right boundary of tree (exclude leaf) reverse.

```

printBoundary(node) {
    ArrayList<int> ans();
    if (isLeafNode) == false) ans.add(node.data);
    addLeftBoundary(node, ans);
    addLeaves(node, ans);
    addRightBoundary(node, ans);
    return ans;
}
  
```

```

Boolean isLeaf(node) {
    return (root.left == null) && (root.right == null);
}
  
```

```

addLeftBoundary(node, ans) {
    Node cur = root.left;
    while (cur != null) {
        if (isLeaf(cur) == false) ans.add(cur.data);
        if (isLeaf(cur) == false) ans.add(cur.data);
        else cur = cur.right;
    }
}
  
```

```
if (isLeaf(cur) == false) ans.add(cur.data);  
if (cur.left != null) cur = cur.left;  
else  
    cur = cur.right;  
    ?
```

addRightBoundary (root, ans) {

 Node cur = root.right;

 ArrayList<int> tmp();

 while (cur != null) {

 if (isLeaf(cur) == false) tmp.add(cur.data);

 if (cur.right != null) cur = cur.right;

 else

 cur = cur.left;

 }

 int i;

 for (i = tmp.size(); i >= 0; i--) {
 ans.add(tmp.get(i));

 }

}

addLeaves (root, ans) {

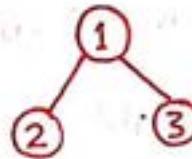
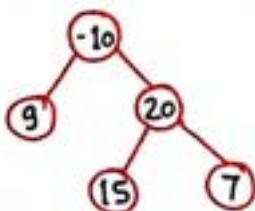
 if (isLeaf(root)) ans.add(root.data);
 return;

 if (root.left != null) addLeaves(root.left, ans);

 if (root.right != null) addLeaves(root.right, ans);

}

★ Binary Tree maximum Path sum



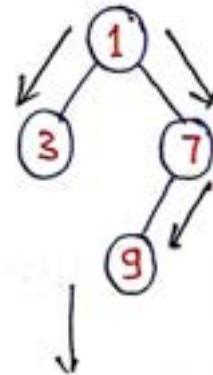
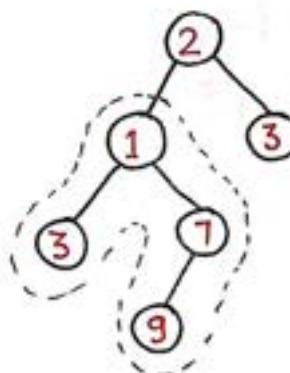
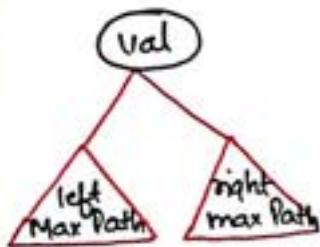
$$2+1+3 = 6$$

most optimal maximum path
sum = $15 + 20 + 7 = \underline{42}$

A bruteforce approach would be to generate all paths and compare them. Generating all paths will be a time costly activity therefore we need to lookup for something else.

At a given node with a val, if we find the max left sum path in the left subtree and right sum path in the right subtree,

$$\text{maxPathSum} = \text{val} + \text{leftSumPath} + \text{rightSumPath}$$



- Initialize a maximize to store final ans.

- Do a simple tree traversal at each node, find recursive its leftMaxPath and rightMaxSum path.

- cal. the $\text{val} + \text{leftMaxPath} + \text{rightMaxSum}$ and update maxi accordingly.

- Return the maxPath when node is not the curving point as $\text{val} + \max(\text{leftMaxPath}, \text{rightMaxPath})$.

$$\text{left path} = 3$$

$$\text{right path} = 1 + 7 + 9 = 16$$

$$\begin{aligned} \text{max Path Sum} &= \text{val} + \text{left path} + \\ &\quad \text{right path} \end{aligned}$$

$$= 3 + 1 + 16$$

$$= 20$$

```

maxPathSum (root) {
    int maxVal [] = new int [1];
    maxVal [0] = Integer.MIN_VALUE;
    maxPathDown (root, maxValue);
    return maxValue [0];
}

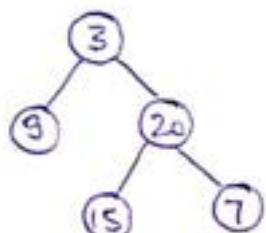
maxPathDown (node, maxValue) {
    if (node == null) return 0;
    int left = Math.max (0, maxPathDown (node.left, maxValue));
    int right = Math.max (0, maxPathDown (node.right, maxValue));
    [ maxValue [0] = Math.max (maxValue [0], left + right + node.val); ]
    return Math.max (left, right) + node.val;
}

```

} ↳ return to its parent

backtrack
logic.

Construct a Binary Tree from inorder and pre order - Problem - 120



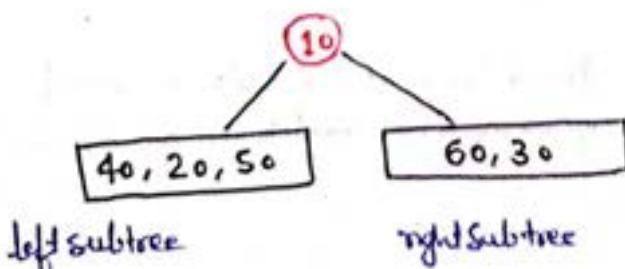
Input: [3, 9, 20, 15, 7]

Output: [9, 3, 15, 20, 7]

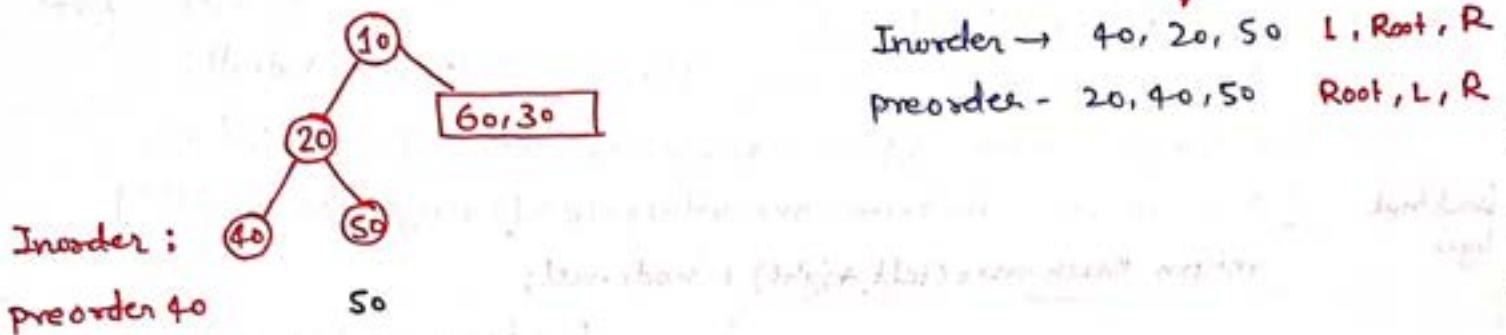
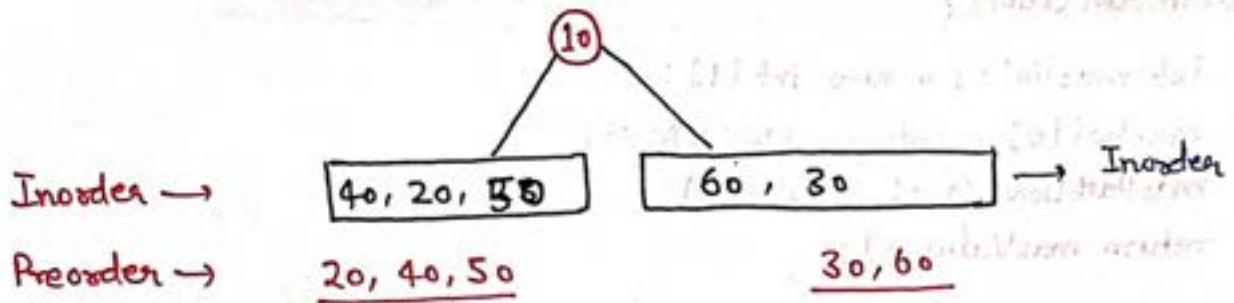
Output: [3, 9, 20, null, null, 15, 7]

Input: inorder → [40, 20, 50, 10, 60, 30] ↲ left, root, right
 preorder → [10, 20, 40, 50, 30, 60] ↲ root, left, right

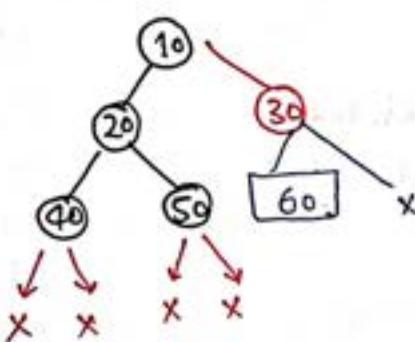
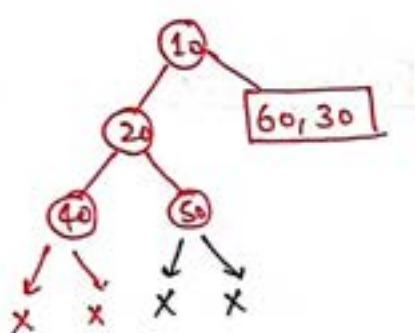
$\xrightarrow{\text{left}}$ ↓ $\xrightarrow{\text{right}}$
 ↑ root



order can be anything
 we only consider the left
 and right part

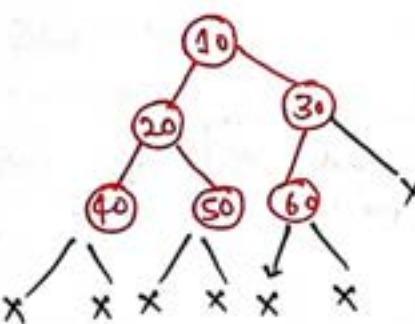


Inorder - 40 Inorder: 50
preorder - 40 preorder: 50

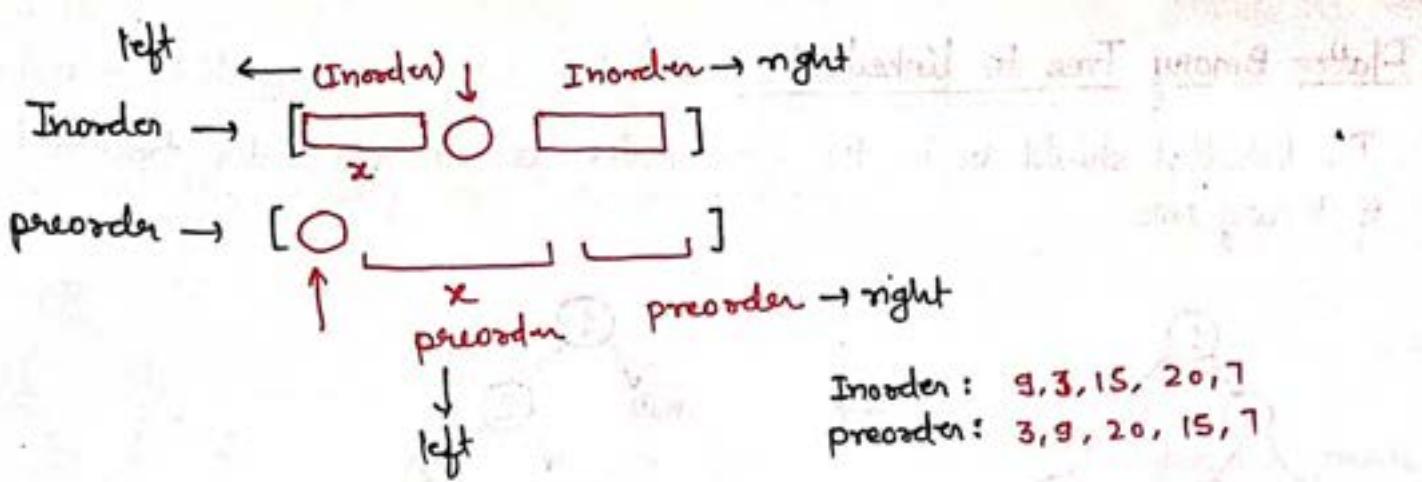


Inorder - 60, 30
preorder - 30, 60

Inorder - 60
preorder - 60



breakdown the problem and
generate the subtree.



```
main (preorder[], inorder[]) {
    HashMap<int, int> map();
    for (i = 0; i < inorder.length; i++) {
        map.put (inorder[i], i);
    }
}
```

9	\rightarrow	0
3	\rightarrow	1
15	\rightarrow	2
20	\rightarrow	3
7	\rightarrow	4

```
TreeNode root = buildTree (preorder, 0, preorder.length - 1, inorder, 0,
                           inorder.length - 1, map);
```

```
return root;
```

```
}
```

```
buildTree (preorder, int prestart, int preEnd, inorder[], int instart,
           int inEnd, map) {
```

```
if (prestart > preEnd || instart > inEnd) return null;
```

```
TreeNode root = new TreeNode (preorder[prestart]);
```

```
int inRoot = map.get (root.val);
```

```
int numLeft = inRoot - instart;
```

```
root.left = buildTree (preorder, prestart + 1, prestart + numLeft, inorder,
                      instart, inRoot - 1, map);
```

```
root.right = buildTree (preorder, prestart + numLeft + 1, preEnd, inorder,
                        inRoot + 1, inEnd, map);
```

```
return root;
```

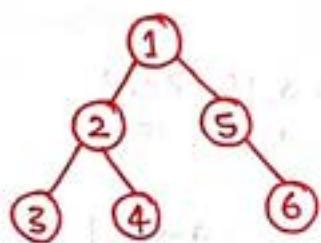
?

Tc - O(N)

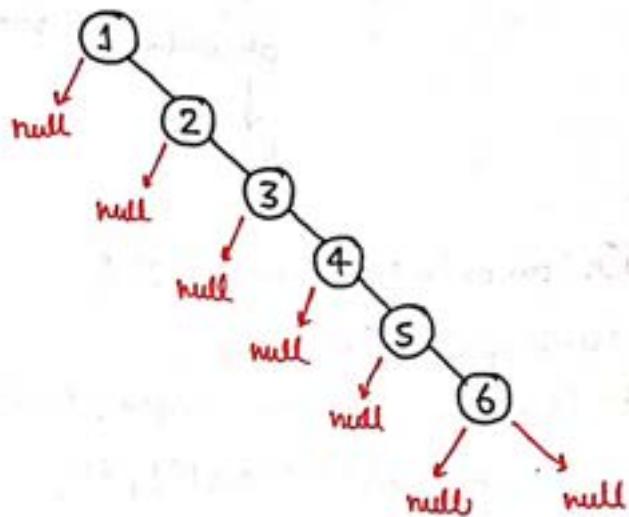
Sc - O(N)

Flatten Binary Tree to linkedlist.

The linkedlist should be in the same order as a pre-order traversal of binary tree.



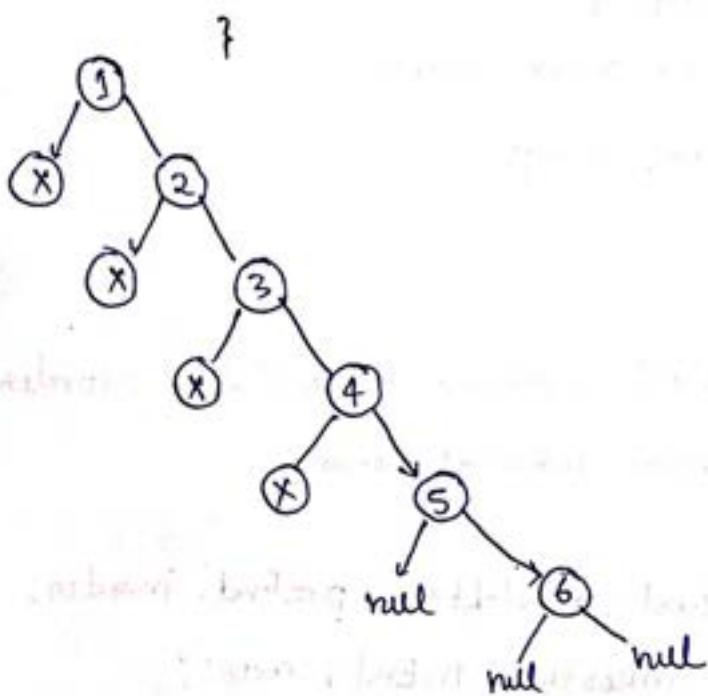
→



class Solution {

```

static Node pre = null;
static void flatten(Node root) {
    if (root == null) return;
    flatten(root.right);
    flatten(root.left);
    root.right = pre;
    root.left = null;
    pre = root;
}
  
```

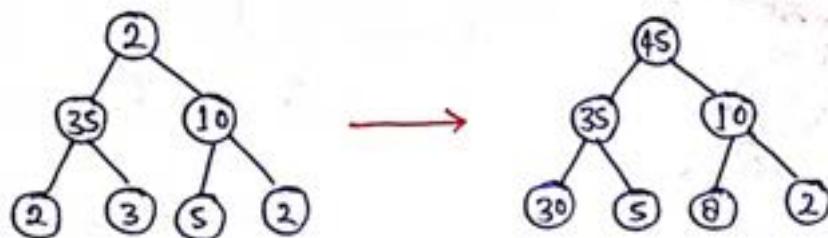


pre = null & 5
4, left, nod
4, right, null
2, left, 3
2, right, 4
2, left, 2
6, left, null
6, right, null
5, right, 6
1, right, 5

↑
Similalry
Root, left, right

Check for children sum property in a Binary Tree -

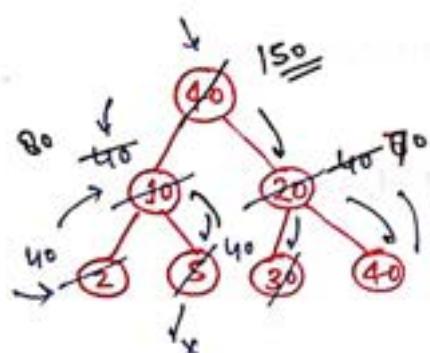
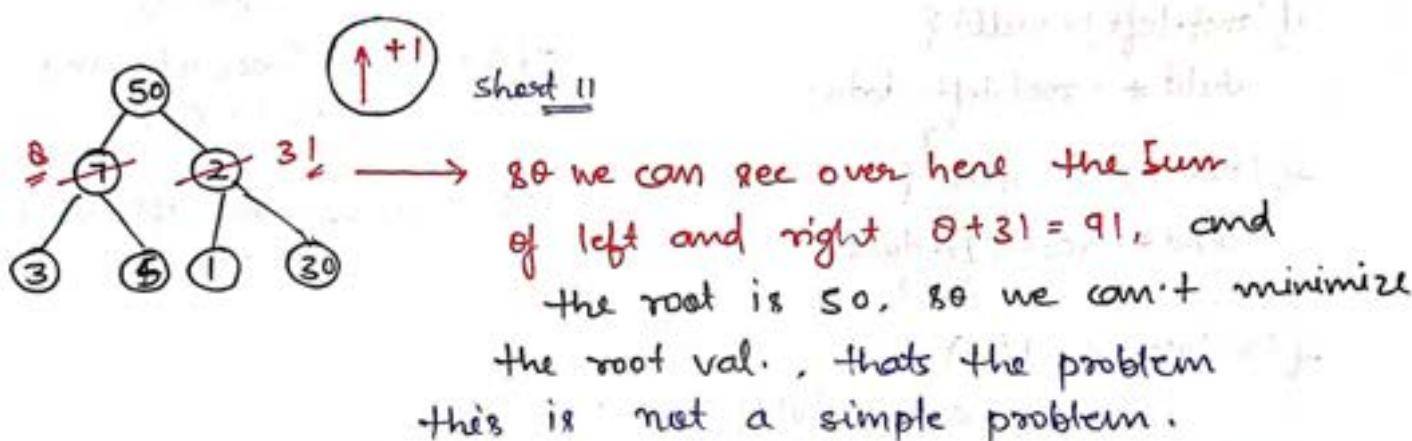
convert the binary Tree into sum tree -



$$\text{node} = \text{left} + \text{right}$$

Note - A val for null node can be accessed 0

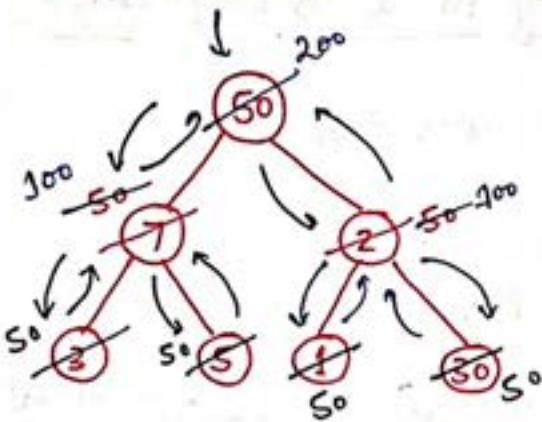
- Not allowed to change the structure.



$$10+20 = 30 < 40$$

$$2+5 = 7 < 40$$

$$30+40 = 70 > 40 \text{ (make root} = \text{left} + \text{right})$$



main()

```

if (root == null) return;
int child = 0;
if (root.left != null) {
    child += root.left.data;
}
if (root.right != null) {
    child += root.right.data;
}
if (root.data <= child)
    root.data = child;
else {
    if (root.left != null)
        root.left.data = root.data;
    else if (root.right != null)
        root.right.data = root.data;
}
  
```

Selffun recursion (root.left);

Selffun recursion (root.right);

```

int tot = 0;
if (root.left != null)
    total += root.left.data;
if (root.right != null)
    total += root.right.data;
if (root.left == null || root.right == null)
    root.data = tot;
  
```

$7+2 = 9 < 50$ [make left and right S°]

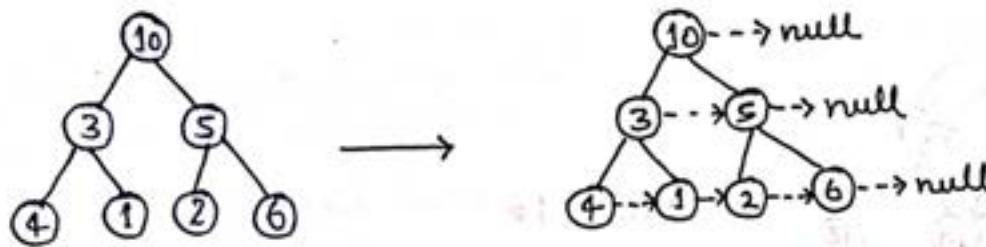
$3+5 = 8 < 50$ [make left and right S°]

$1+30 = 31 < 50$ [make left and right S°]

Tc - O(N)

Sc - O(H)

Connect nodes at the same level



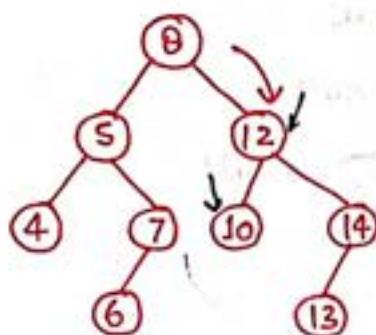
connect(root)

```
Queue<Node> q();
q.add(root);
Node temp = null;
while (!q.isEmpty()) {
    int n = q.size();
    for (i=0; i<n; i++) {
        Node pre = temp;
        temp = q.poll();
        if (i > 0) {
            pre.nextRight = temp;
        }
        if (temp.left != null)
            q.add(temp.left);
        if (temp.right != null)
            q.add(temp.right);
    }
    temp.nextRight = null;
}
```

Time complexity - O(N)

Search In a Binary Tree

BST $\rightarrow (\log_2 N)$



node = 10

L < N < R

It is a BST so we can see that 8 is less than 10 so 8 is less than 10 so 10 could be lie in right.

12 is greater than 10 so goto 10

10 == val ↙

if reach null return null:

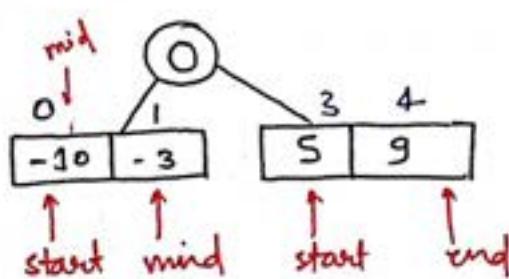
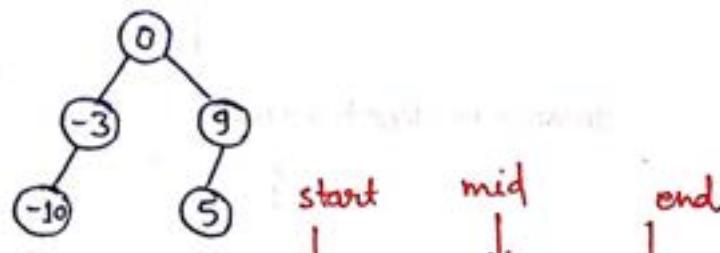
```

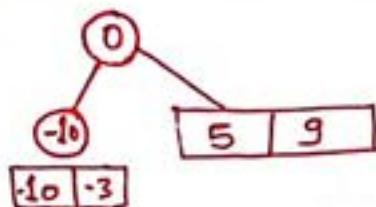
while (root != null && root.val != val) {
    root = val < root.val ? root.left : root.right;
}
return root;
  
```

Convert sorted Array to Binary Search Tree

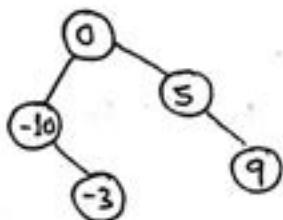
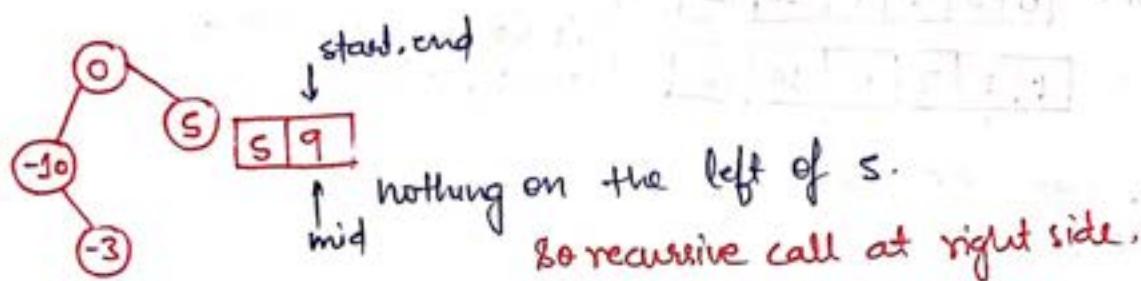
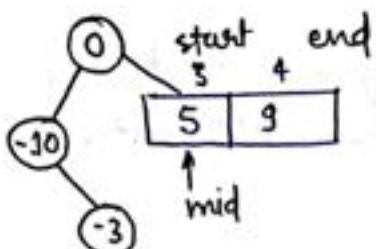
arr = [-10, -3, 0, 5, 9]

clearly show the root will be the mid element.





there is nothing on the left of -10 make a recursive call on right side.



```

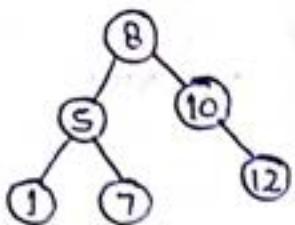
main(arr) {
    return help(arr, 0, arr.length - 1);
}

help(arr, start, end) {
    if (start > end) return null;
    int mid = (start + end) / 2;
    Node node = new Node(arr[mid]);
    node.left = help(arr, start, mid - 1);
    node.right = help(arr, mid + 1, end);
    return node;
}
  
```

BST from pre-order Traversal -

preorder -

8	5	1	7	10	12
---	---	---	---	----	----



Better solution - we know that preorder traversal is given and if we know the Inorder so we can construct the BST with help of both the traversal.

preorder -

8	5	1	7	10	12
---	---	---	---	----	----

Inorder -

1	5	7	8	10	12
---	---	---	---	----	----

} So we can create the BST by this.

$$T_c = O(N \log N) + O(N)$$

$$S_c = O(N)$$

Optimal solution -

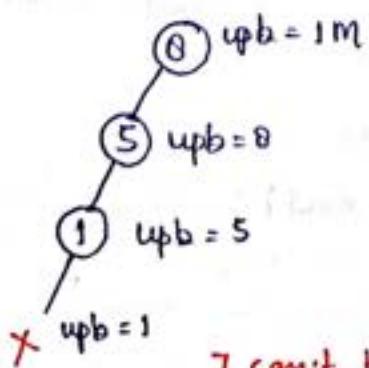
take the upperbound initially at 1M.

firstly check 8 is under the upperbound or not (yes it is).

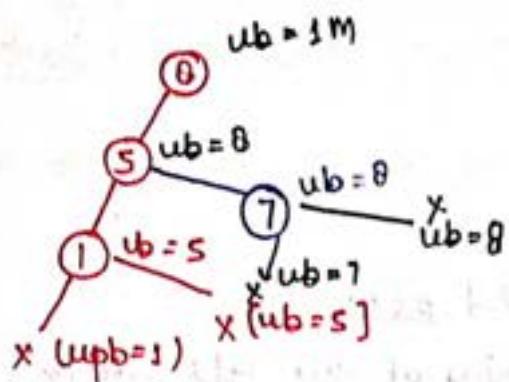
⑧ upb = 1M

we dont know how many element that will lie at the left side of 8.

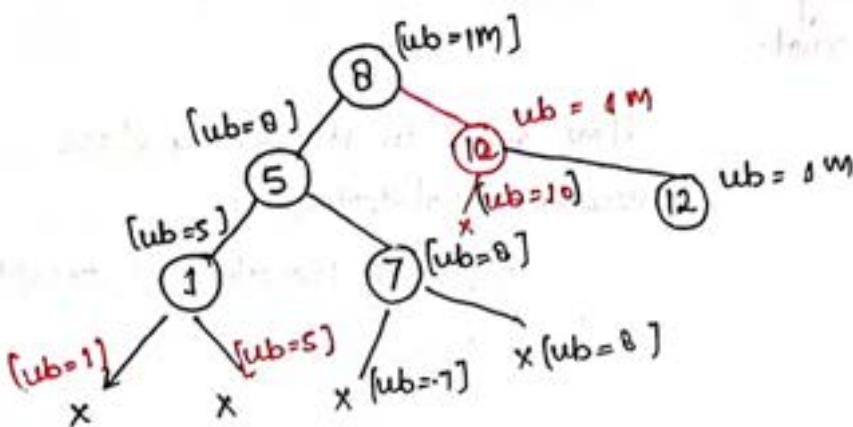
We know one thing for sur. everything at the left will always smaller than 8.



7 can't be on left. so it assign null



0	5	1	7	10	12
---	---	---	---	----	----



If we are calling left, then we have to pass that val. as a bound.
 $\{(left, node.val)\}$

If we are calling right, then we have to the val. which is prev. Bound.

$\{(right, bound)\}$

Tc - we are traversing a singal node 3 times.

Tc - $O(3N) \approx O(N)$

Sc - $O(1)$.

main (int arr){

return help (arr, INT_MAX, new int[] {0});

 }

 help (arr, bound, int[] i){

 if (i[0] == arr.length || arr[i[0]] > bound) return null;

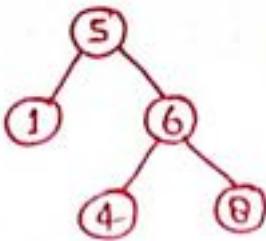
 TreeNode root = new TreeNode (arr[i[0]+1]);

 root.left = help (arr, root, val, i);

 root.right = help (arr, bound, i);

 return root;

Check BT is BST or not.



The valid BST:

- * everything at the left has to be smaller than that node
- * and everything at the right has to be greater.

By this we the intuition come in our mind we will pass a range and ask every node try. you will lie at this range or not.

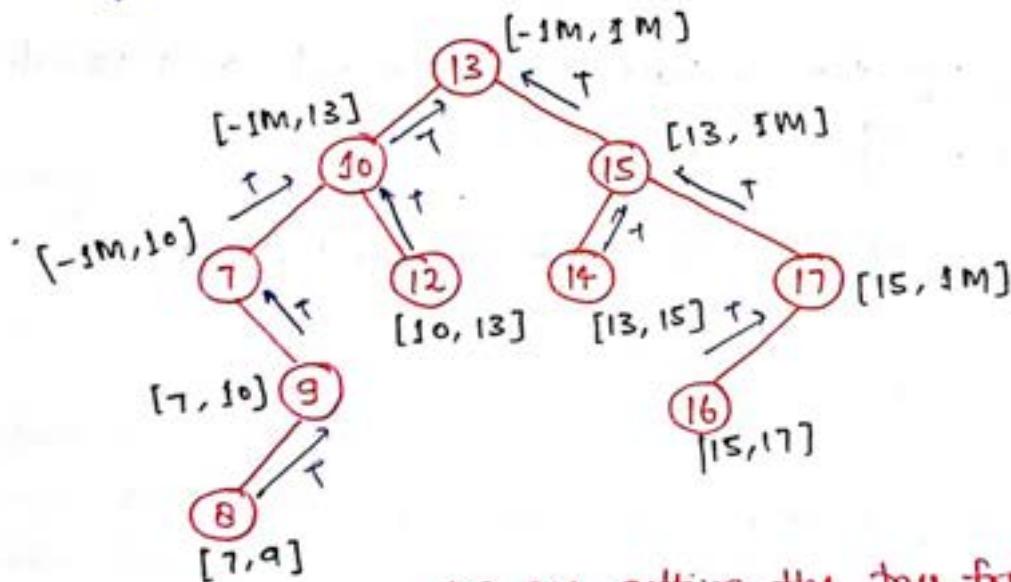
Range - [l, h]

Here 4 is in the wrong place because validation is.

$\underline{s} < \underline{4} < \underline{6}$ (which not accepted).

Range [s, e]

Initial range [-1M, 1M]



we are getting the tree from both

the subtrees.

so its a valid BST.

Tc - O(N)

Sc - O(1)

main(root) { return help(root, LONG_MIN, LONG_MAX); }

help(root, long minval, long maxval) {

if (root == null) return true;

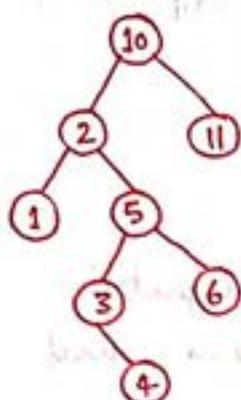
if (root.val >= maxval || root.val < minval)
return false;

return help(root.left, minval, root.val) && help(root.right,

root.val, maxVal);

Predecessor and Successor

A key is given to us and we have to search in the tree for predecessor and successor
 if not found set it to null.



key = 8 , output = [6, 10]

It is a bst so we can decide that we have to go to the left subtree/right subtree.

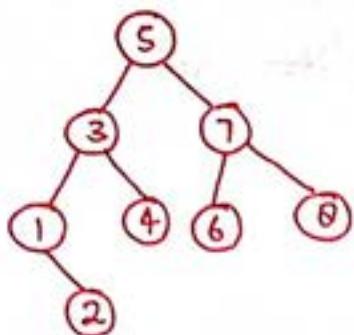
```
main(root) {
    predecessor(root, key);
    successor(root, key);
}
```

```
predecessor(root, key) {
    while (root != null) {
        if (root.data >= key) {
            root = root.left;
        }
        else {
            pre = root.data;
            root = root.right;
        }
    }
}
```

```
successor(root, key) {
    while (root != null) {
        if (root.data <= key) {
            // successor = root.data;
            // root = root.left;
            root = root.right;
        }
    }
}
```

```
else {
    successor = root.data;
    root = root.left;
}
```

Kth smallest element in a BST - / largest element



$K=3$, we have to find the 3rd smallest solution.

Naive solution - take an ArrayList and do the traversal put all the elements of tree into the list and sort them and in the last get the Kth element.

$$Tc = O(N) + O(N \log N)$$

$$Sc = O(N)$$

Efficient solution -

Inorder - Left, node, Right.

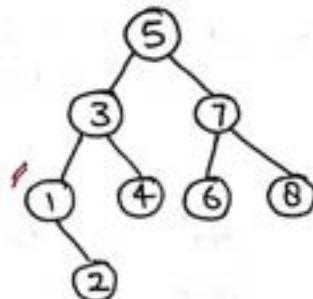
1, 2, 3, 4, 5, 6, 7, 8
Inorder traversal

If we use the inorder traversal so it gives all the elements in a sorted order.

by this we remove $O(N \log N)$ for sorting.
Now our task is to remove $O(N)$ extra space.

take a cnt variable and make sure if we are visiting the node then we have to increase the cnt by 1.

if (cnt == k)
 ans = node



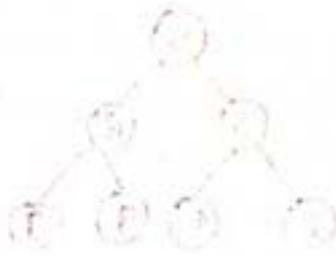
$$Tc = O(N) \quad] \text{Recursion}$$

$$Sc = O(N)$$

if we have to find k^{th} largest.

One traversal - $O(N)$

k^{th} largest = $(N - k^{\text{th}})$ smallest



k^{th} smallest(root , int k) {

 return help(root , new int [] { k });
 }

help(root , int k){

 if ($\text{root} == \text{null}$) return null;

 Node left = help($\text{root} \cdot \text{left}$, k);

 if ($\text{left} != \text{null}$)

 return left;

$k[0]--$;

 if ($k[0] == 0$) return root ;

 return help($\text{root} \cdot \text{right}$, k);

} Logic - 1

private int cnt = 0;

private int res = 0;

k^{th} smallest(root , k) {

 traverse(root , k);

 return result;

 }

} Logic - 2

traverse(root , k) {

 if ($\text{root} == \text{null}$) return null;

 traverse($\text{root} \cdot \text{left}$, k);

 cnt++;

 if ($\text{cnt} == k$)

 { res = $\text{root} \cdot \text{data}$;

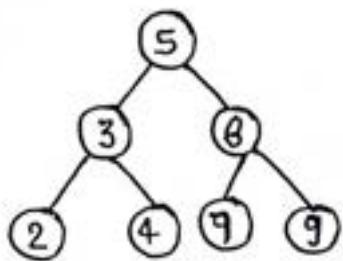
 return;

 }

 traverse($\text{root} \cdot \text{right}$, k);

}

Pair with given Sum in BST

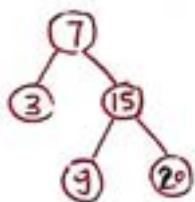


We can solve this problem using HashSet.

```

static Set<int> st;
main (root, k) {
    st = new HashSet<>();
    return help(root, k);
}
help (root, k) {
    if (root == null) return false;
    if (st.contains (root.val + k)) return true;
    st.add (root.val);
    return help (root.left, k) || help (root.right, k);
}
  
```

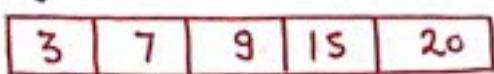
Binary Search Iterator



So we have to design a class of functions so we can operate this operation.

BSTIterator(7) → root
 next → inorder's guy.
 next → 3
 next → 7
 hasNext → yes.
 next → 9
 hasNext → yes
 next → 15
 hasNext → yes
 next → 20
 hasNext → no

if we take an array store all the integers so we can perform the operations easily.



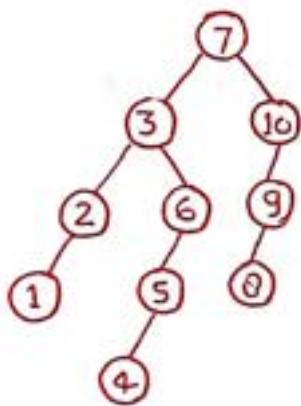
next → 3

harvest → yes

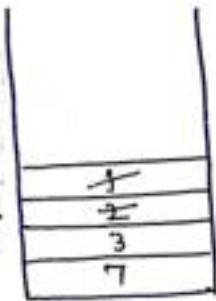
it will be easy.

But the $T_C = O(1)$ and $S_C = O(N)$, because we are storing all the values in the array.

Inorder - L, N, R



(class → BSTIterator(7))



stack .

we will go in extreme left , so we will do in the construct
we will go in extreme left . and put everything into stack

Now if someone calls `l's next`, & it's null , so check the stack's first element.

when again next called, does 2 have
a right.

next - 1.

next - 2

next → 3

check 3 has a right?

yes it has

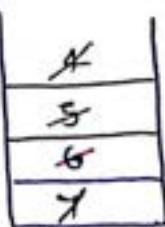
Go to right,

Now put everything into stack.

Similarly 5 and 4 added because left is called for 6.

Now 4 left will be null.

Now if some say. `h->next` ?
empty, then return true;



Just check if stack is not

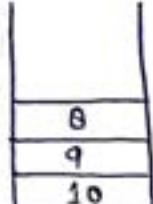
`next -> 4`

4 doesn't have a right

`next -> 5 5 " " "`

`next -> 6 6 " " "`

`next -> 7 yes 7 have a right , put all the element`



Similar things will happen.

SC - O(H)

TC - O(1)

class BSTIterator {

 private Stack <TreeNode> st = new Stack <>();

 public BSTIterator (root) {

 pushAll (root);

}

 private void pushAll (root) {

 for (; node != null ; st.push (node), node = node.left);

}

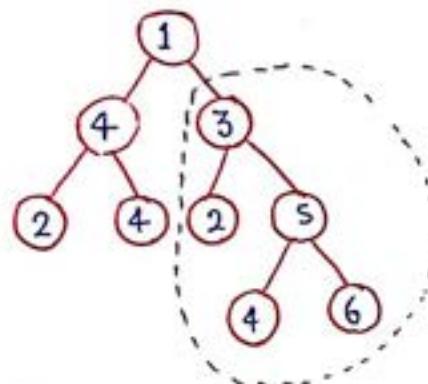
```

public boolean hasNext() {
    return !st.isEmpty();
}

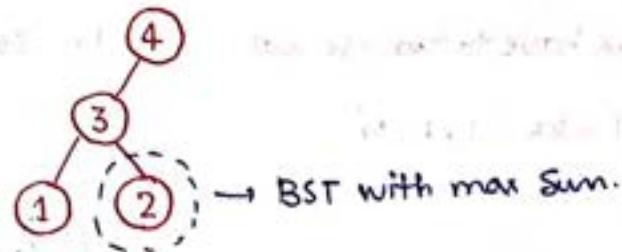
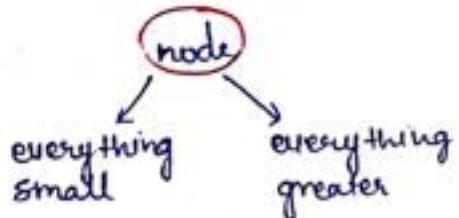
public int next() {
    TreeNode node = st.pop();
    pushAll(node.right);
    return node.val;
}

```

Maximum Sum in BST in a Binary Tree



this is a BST with a max sum.

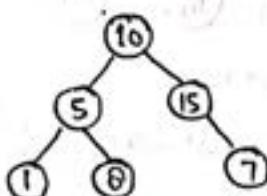


→ BST with max sum.

Bruteforce - I will validate the BST.

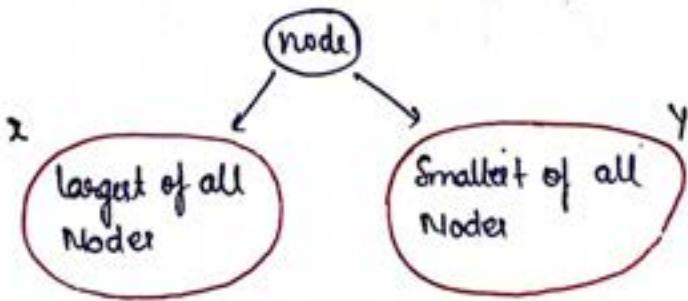
So take a min max and validate by going on every node

to → validate BST.
5 ← yes



validate BST → $O(N) \times O(N) = O(N^2)$

↓
going to every node



$$\text{Size} = l + x + r$$

largest < node < smallest

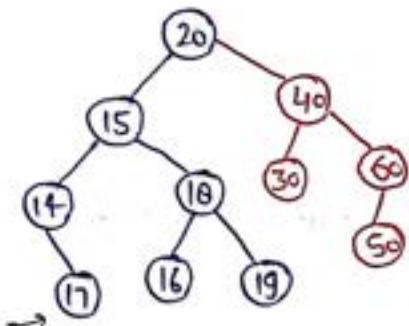
We will go to bottom and we know the bottom guy will be a BST \rightarrow for sure. and it's connected to a node.

Idea - Build the things from bottom.

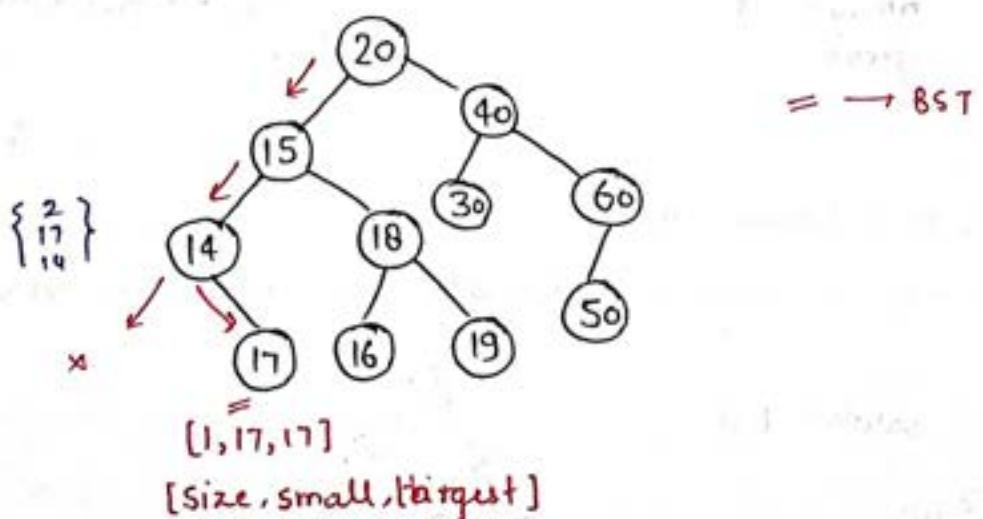


if satisfied the condition
the BST

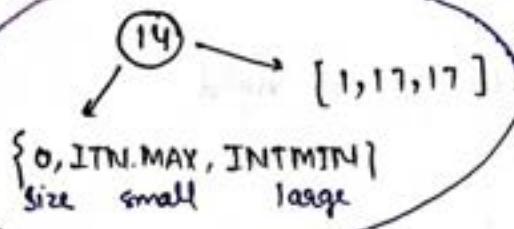
store the largest, smallest and size.



We have to transversal L, R, N so we take all element, L and R
postorder - L, R, N



If there is no node on left and right so pass the dummy node of
size $\rightarrow 0$, for largest take INT-MIN and for smallest take
INT-MAX.

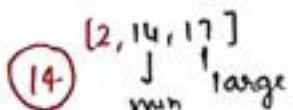


→ So when will be this will be a valid BST.

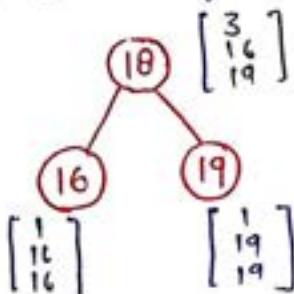
for 14 to be a valid BST.

$$INTMIN < 14 < INTMAX$$

for 14 → size will be $1+x+y \Rightarrow 1+0+1 = 2$



Now for 15 the left is completed.



So if come to 18 so check.

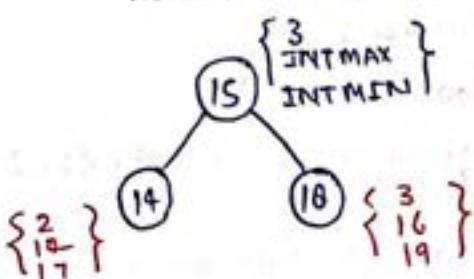
node, which is 18, is greater than largest of left subtree and smaller than the smallest of right subtree.

$$16 < 18 < 19 \rightarrow \text{Yes}, \text{ so } 18, \text{ will contain BST.}$$

$$\text{Size for } 18 \rightarrow 1+x+y = 1+1+1 = 3$$

Now come to 15.

At the moment we come to 15., look at largest of left 17 and minimal of right 16



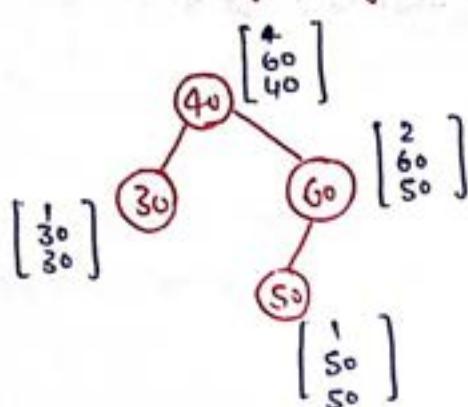
$$17 < 15 (\times \text{ not following})$$

right is OK but left not

Not in that condition pass the INTMIN and MAX

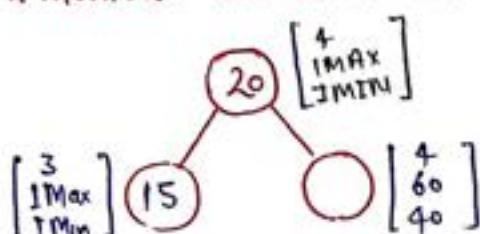
we pass MIN and MAX so comparison wont be possible in future.

Now everything in left of 20 completed go to right.



$$30 < 40 < 50 \text{ (true)}$$

At moment we came 20.



$$\underline{\text{INTMAX}} < \underline{20} < \underline{40}$$

X ✓

But largest BST

if BST.size = 1 + x + y otherwise = max(left, right)

Tc - O(N)

Sc → O(1)

```
class NodeValue {
```

```
    public int maxNode, minNode, maxSize;
```

```
    NodeValue { int maxNode, minNode, maxSize } {
```

```
        this.maxNode = maxNode;
```

```
        this.minNode = minNode;
```

```
        this.maxSize = maxSize;
```

```
}
```

class Solution {

```

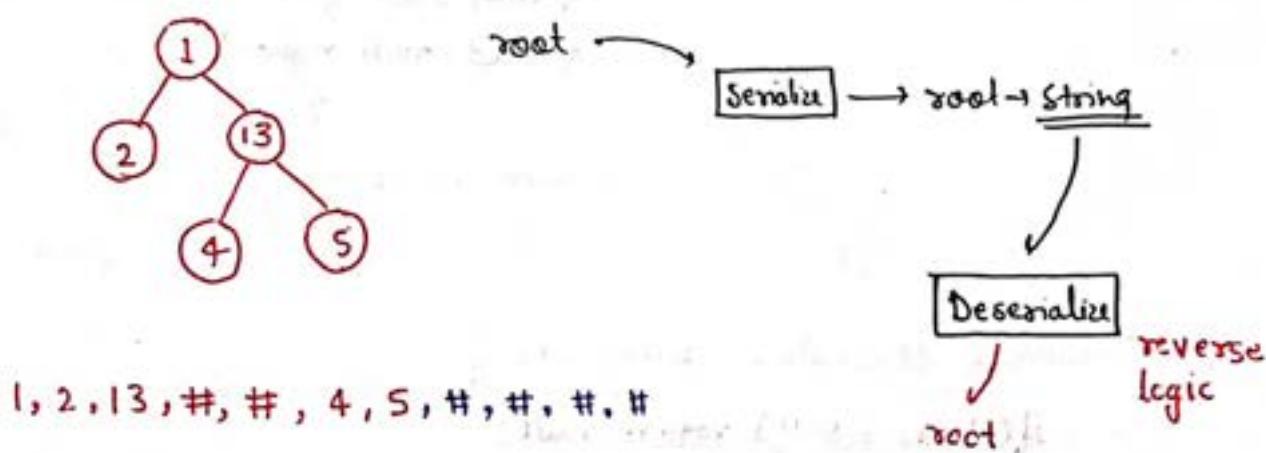
main(root) {
    if (root == null) {
        return new NodeValue (INT-MAX, INT-MIN, 0);
    }
    Node left = main(root.left);
    Node right = main_(root.right);

    if (left.maxNode < root.val && root.val < right.minNode) {
        return new NodeValue (Math.min (root.val, left.minNode), Math.max (root.val,
            right.maxNode),
            (left.maxSize + right.maxSize + 1));
    }
    return new NodeValue (INT-MIN, INT-MAX, max (left.maxSize, right.maxSize));
}

in() {
    return main_(root).maxSize;
}

```

Serialize and Deserialize Binary Tree



Make sure there have a null on leaf node

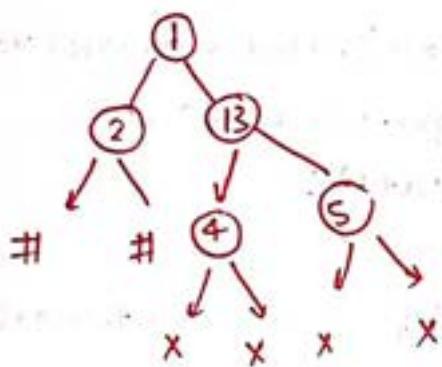
Now we have serialize -

the string we get: 1, 2, 13, #, #, 4, 5, #, #, #
↑ ↑

Now for deserialize -

take queue ds.

8
4
13
2
5



```
public String serialize(TreeNode root) {  
    if (root == null) return "";  
    Queue<TreeNode> q = new LinkedList<>();  
    StringBuilder res = new StringBuilder();  
    q.add(root);  
    while (!q.isEmpty()) {  
        TreeNode node = q.poll();  
        if (node == null) {  
            res.append("n ");  
            continue;  
        }  
        res.append(node.val + " ");  
        q.add(node.left);  
        q.add(node.right);  
    }  
    return res.toString();  
}
```

```
public TreeNode deserialize(String data) {
```

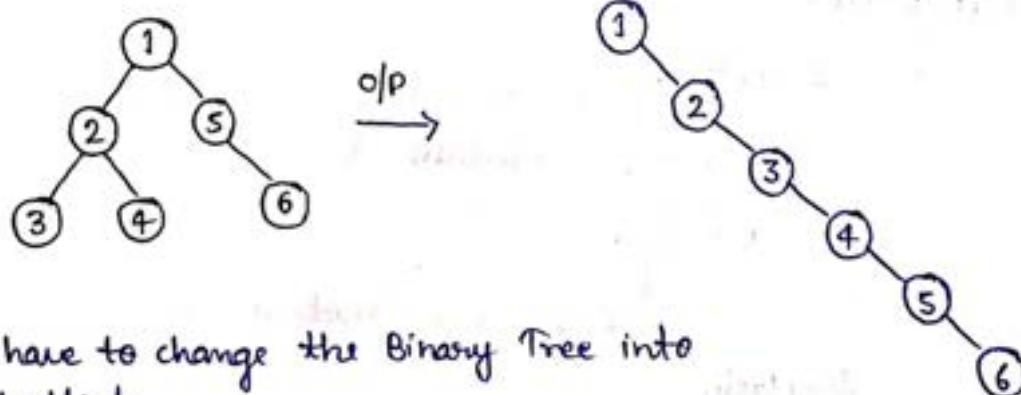
```
    if (data == "") return null;  
    Queue<TreeNode> q = new LinkedList<>();  
    String[] values = data.split(" ");
```

```

TreeNode root = new TreeNode (Integer.parseInt(values[0]));
q.add(root);
for (int i=1; i<values.length; i++) {
    TreeNode parent = q.poll();
    if (!values[i].equals("n")) {
        TreeNode left = new TreeNode (Integer.parseInt(values[i]));
        parent.left = left;
        q.add(left);
    }
    if (!values[++i].equals("n")) {
        TreeNode right = new TreeNode (Integer.parseInt(values[i]));
        parent.right = right;
        q.add(right);
    }
}
return root;
}

```

Flatten Binary Tree to linkedlist :-



we have to change the Binary Tree into linkedlist.

The thing we have to observe -

so 6 is at the bottom.

If we see the output at the left

The conditions -

- linkedlist should use the same `TreeNode` class where the right child pointer points to the next node in the list and the left child pointer is always null.

class Solution {

```
    TreeNode pre = null;
```

```
    flatten(TreeNode root) {
```

```
        if (root == null) return;
```

```
        flatten(root.right);
```

```
        flatten(root.left);
```

```
        root.right = pre;
```

```
        root.left = null;
```

```
        pre = root;
```

```
}
```

```
}
```

find Median from Data Stream.

The Number are coming in the array stream and at any moment it can ask us for the midian.

Median → We can find the median if arr is sorted

if new Number is added so it has to be add at the exact and correct place.

3, 1, 5, 4 . . .

a → 3 , median = 3

a = 3, 1

↓

sort → 1, 3 median = 2

Similarly

a = 1, 3, 4, 5 median = 3.5

so for putting all the Number in the stream in the exact place to make sorted -

Tc - O(N) and there are N

Number so it will take - O(N²)

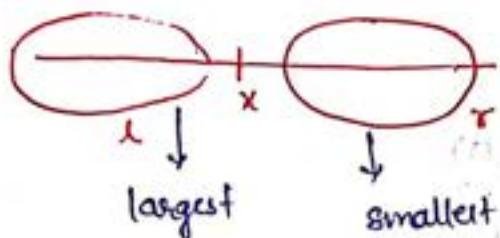
Optimize -

Observation is we don't have to sort this we just need to return the median., and we know median the middle number.

3 (median) additional

smaller < median < greater

if x is a median so
the Number on right side will be equal to left side.



so we can find the median with the help of left part largest number and right part smallest number.

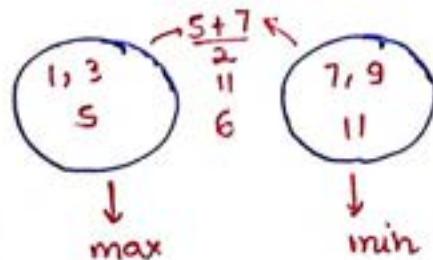
we know we can use maxHeap for getting the max Element

Similarly
for min Heap.

if number is odd to $\frac{n+1}{2}$ element will on left heap and other added to minHeap.

if even so works like as before.

1, 3, 5, 7, 9, 11 → even



if odd so median will largest of maxHeap.

```
class Main {
    Priority Queue<int> maxHeap = new Priority Queue<>(Collections.reverse());
    Priority Queue<int> minHeap = new Priority Queue<>();
    insertNum(int num) {
        if (maxHeap.isEmpty() || maxHeap.peek() >= num) {
            maxHeap.add(num);
        } else {
            minHeap.add(num);
        }
        if (maxHeap.size() > minHeap.size() + 1) {
            minHeap.add(maxHeap.poll());
        } else if (maxHeap.size() < minHeap.size()) {
            maxHeap.add(minHeap.poll());
        }
    }
    double findMedian() {
        if (maxHeap.size() == minHeap.size()) {
            return maxHeap.peek() / 2.0 + minHeap.peek() / 2.0;
        } else {
            return maxHeap.peek();
        }
    }
}
```