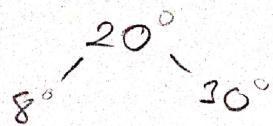


20, 30, 8, 47, 39, 18, 40, 72

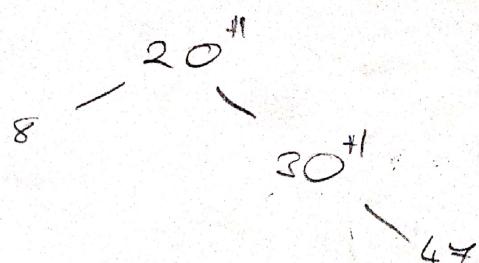
After SNSAR  
15/06/07  
(1)

### 1) AVL tree

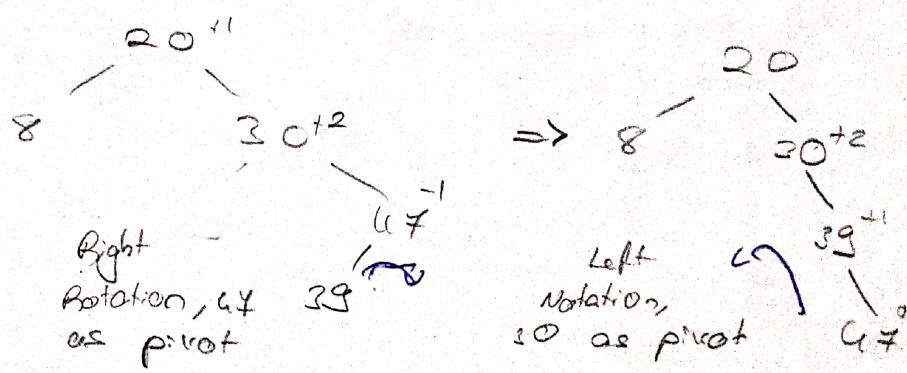
First add



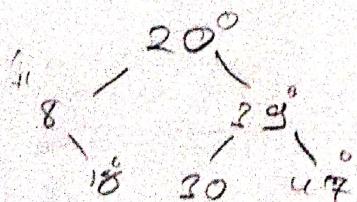
Second add



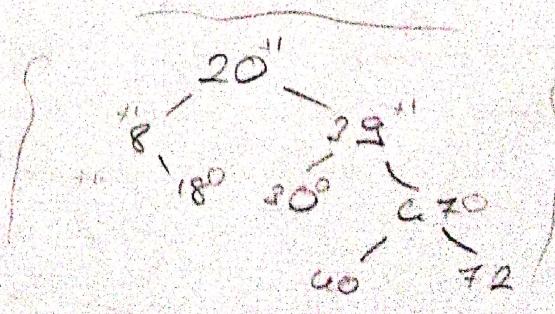
Third add



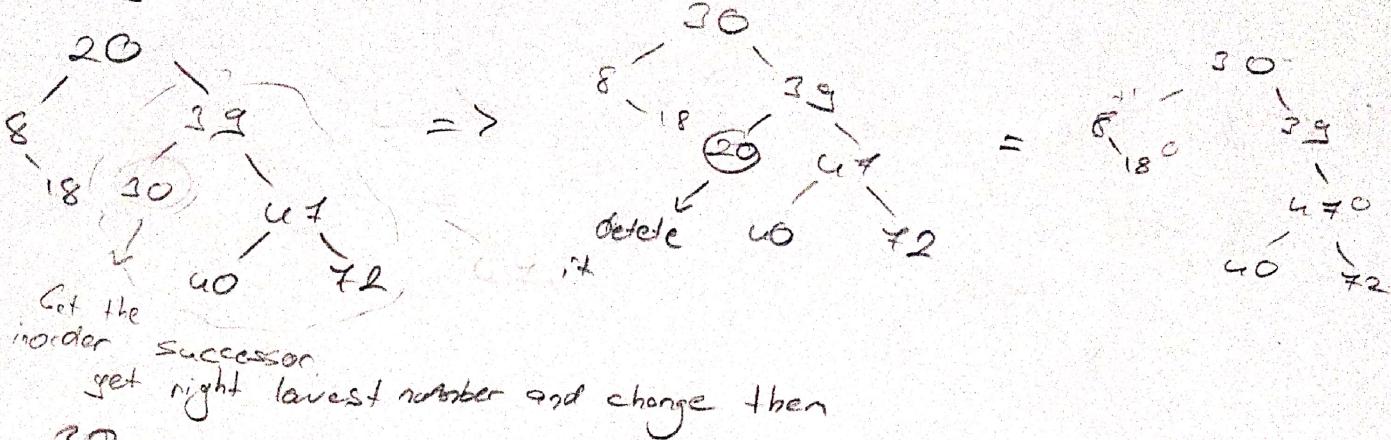
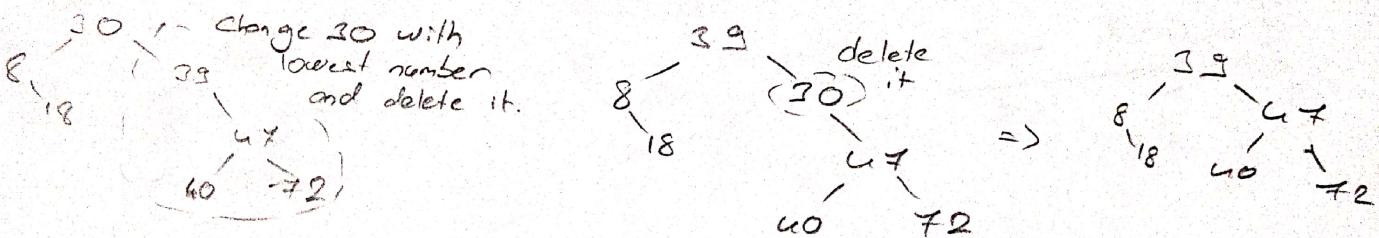
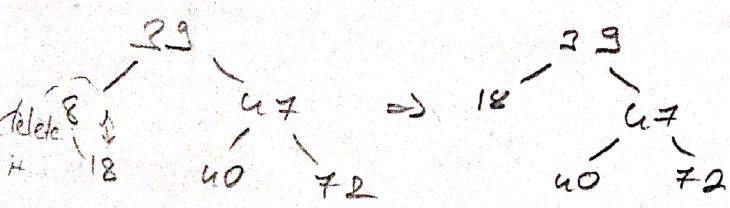
fourth add



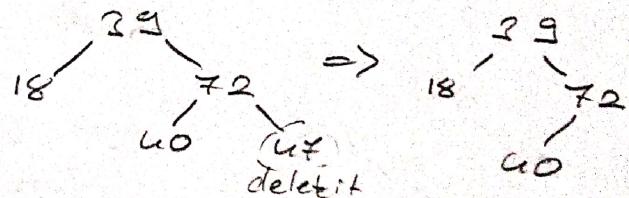
fifth add



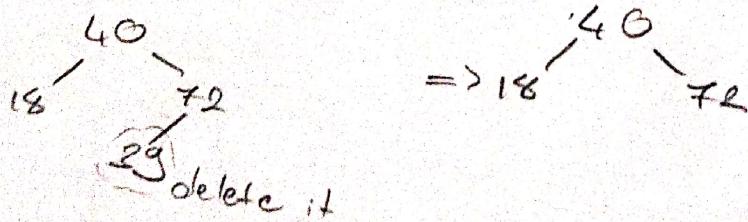
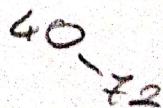
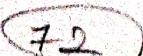
(2)

delete 20delete 30delete 8

delete 47  
change 47 with right lowest number

delete 39

change 14 with right lowest number

delete 18delete 40delete 72

20, 20, 8, 47, 39, 18, 40, 72

## 2) Red-Black Tree

- Red

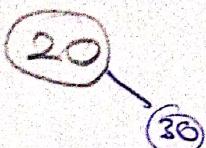
- Black

Add 20



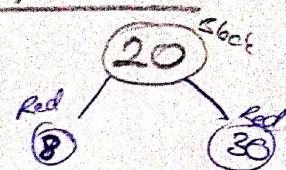
If tree is empty, create new node as black

Add 20



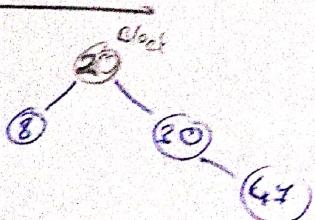
If tree is not empty, create new node as leaf node with color Red

Add 8

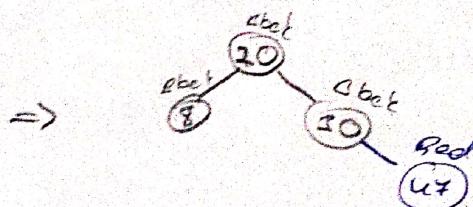


If parent of new node is black done.

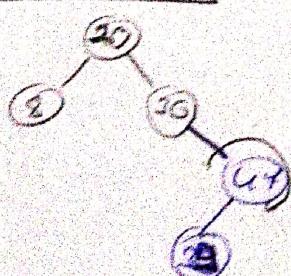
Add 47



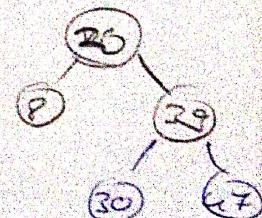
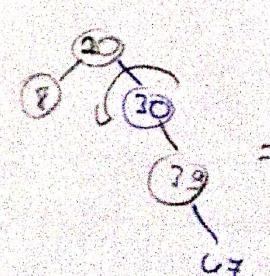
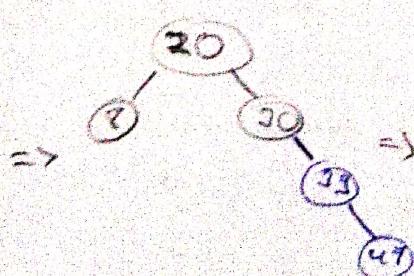
Create new node red  
no two adjacent red nodes;  
redcolor parent and sibling



Add 39

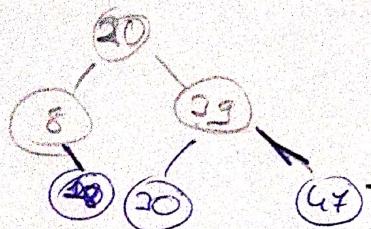


=>



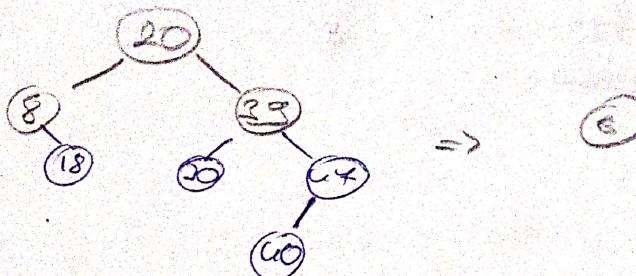
Double rotation

Add 18

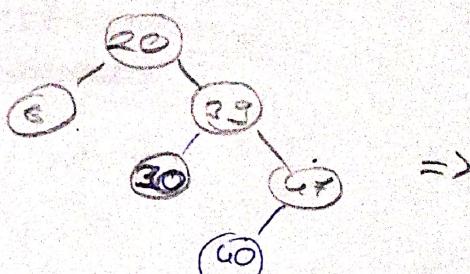


Parent black  
and grandparent is root  
20 done!

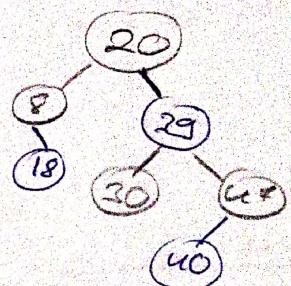
Add 40



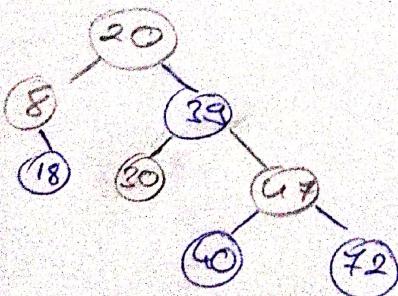
parent and sibling is red  
so not rotation, just recolour.  
parent and sibling recolour to black



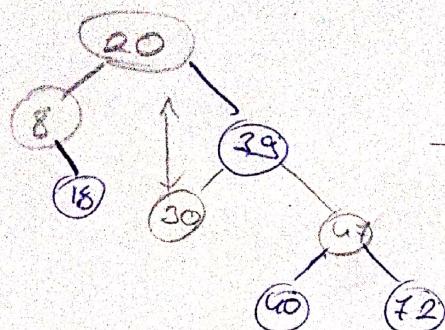
check grandparent  
is not root then  
recolour is red.



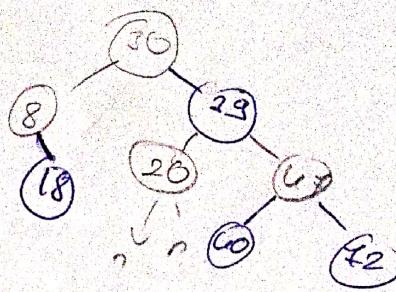
Add 72



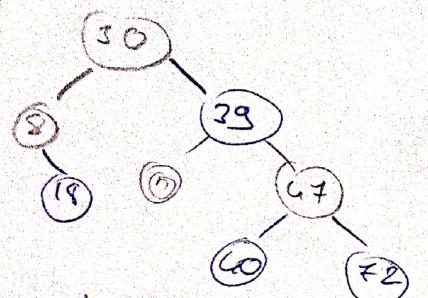
L5

Delete 20

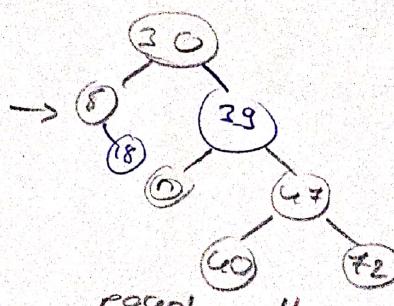
Change 20 with 30  
inorder successor



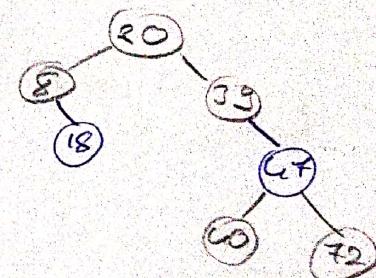
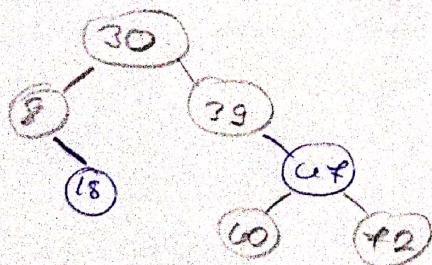
replace it double black



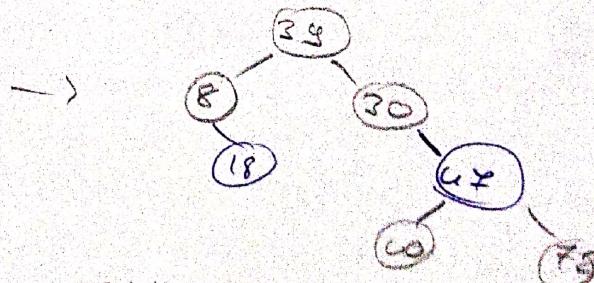
DB's sibling is black;  
color children to black



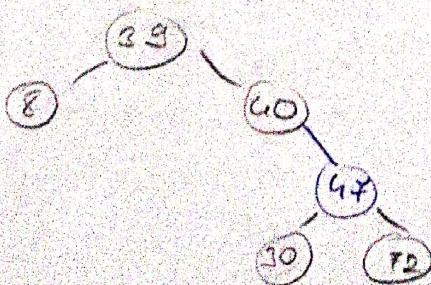
parent will black  
sibling will red

Delete 30

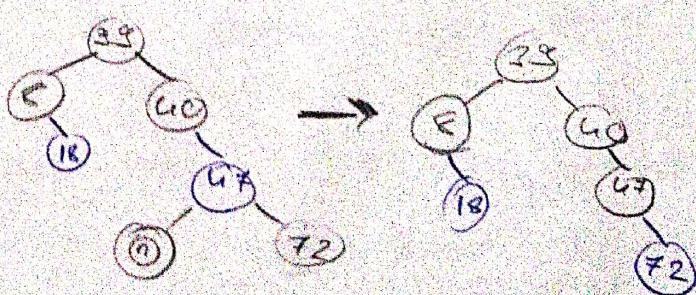
Change with 29  
inorder successor

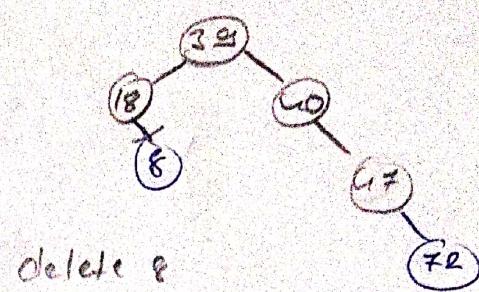
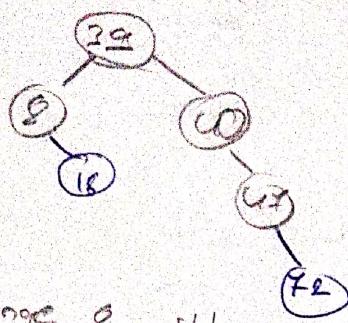


Still is not leaf, change  
with 60, inorder successor.

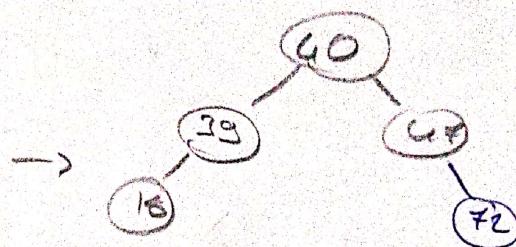
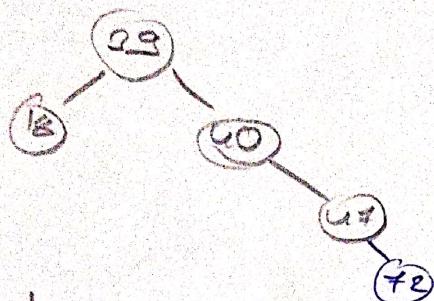


remove DB

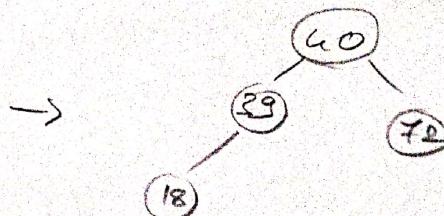
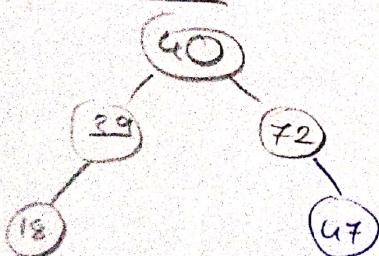


remove 8

Change 8 with 18

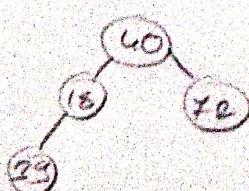


balance it

delete 47

change with 72

and it's red, remove it

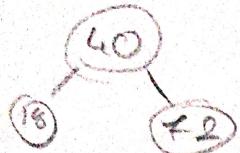
delete 29

change with 18

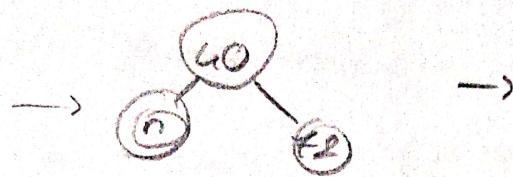
and it is black

root is old remove it

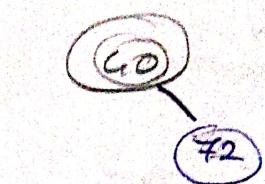
delete 18



remove 18 as a dB

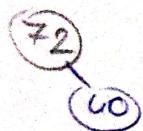


make parent as dB  
sibling red



root is dB remove  
dB

delete 40

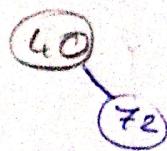


change with 72  
and delete,  
because it is red

delete 72



it is just root deleted



17

## SkipList

height of each node random  
→ from book

2

insert 30

not height

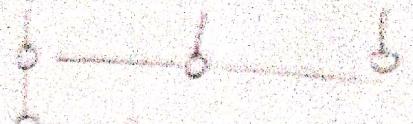
insert 8

not height 2

20 → 30



8 → 20 → 30



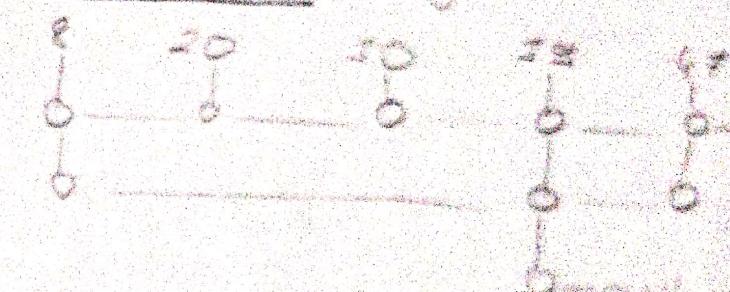
or not

insert 62

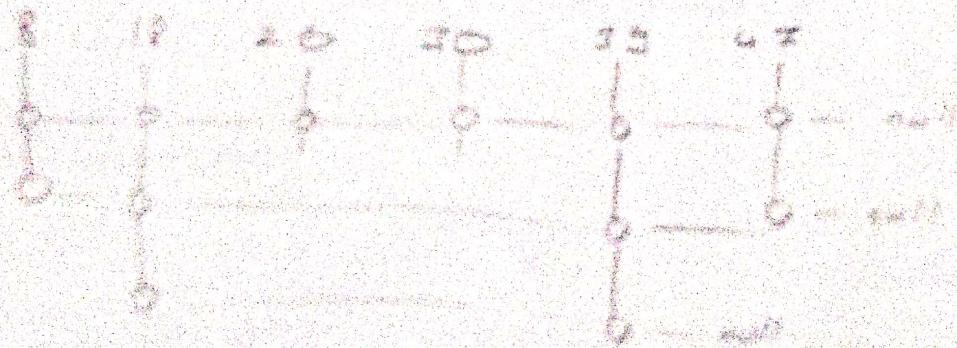
not height 2



insert 33 not height 3



insert 18



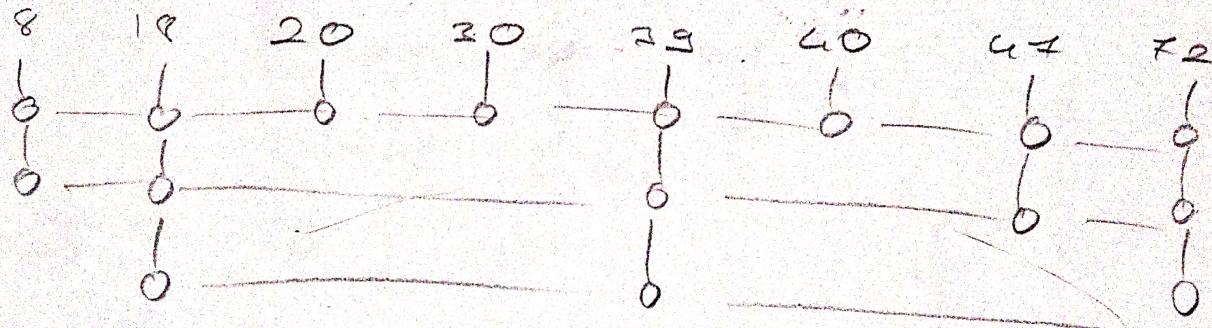
insert 48



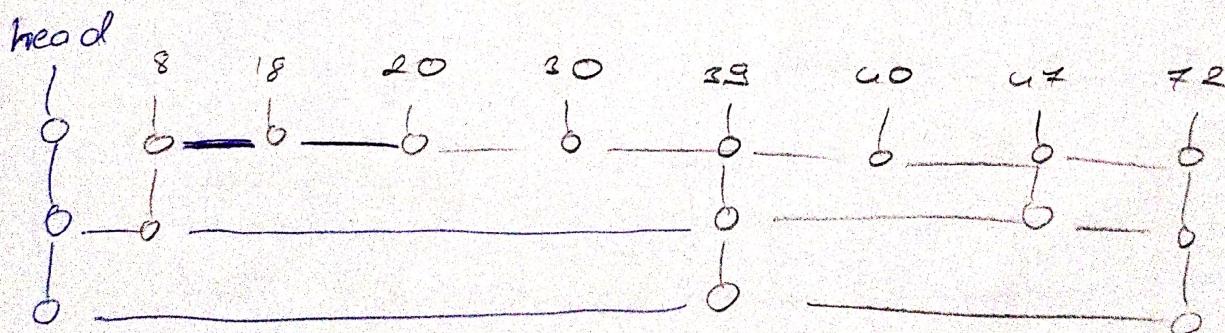
insert 72

Max height 3

3



delete 20



20 less than 39  $\rightarrow$  3. and 2. link

20 bigger than 18  $\rightarrow$  first link

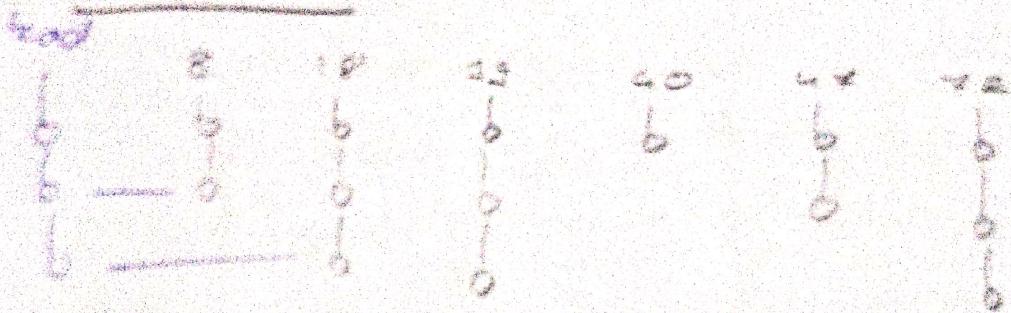
delete 20



10 → 20 left max 15 → 3. max  
→ 2 min

found 20 → first max ✓

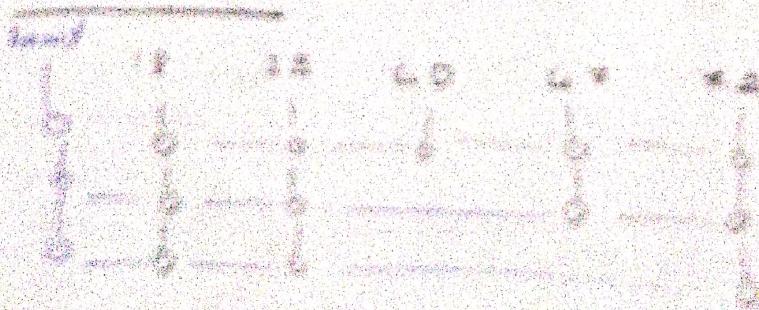
delete 2



2 min 8 was max 10

2 min found 8 ✓

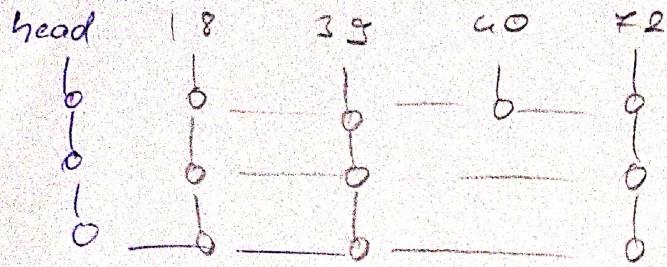
delete 60



60 was max 60 is max

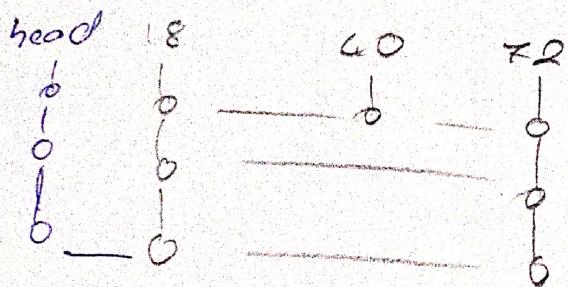
found 60 min ✓

delete 39



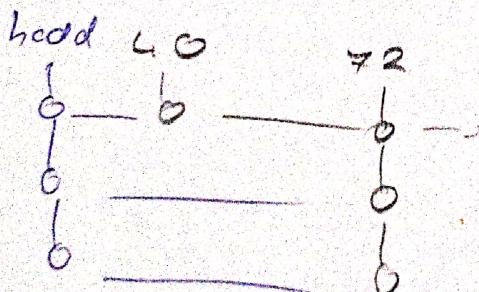
3. link bigger than 18 and found ✓

delete 18



found 3. no &

delete 40

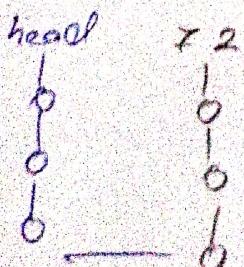


3. link 72 bigger than 40

2. link ↗

first link found ✓

delete 72



2. link found.