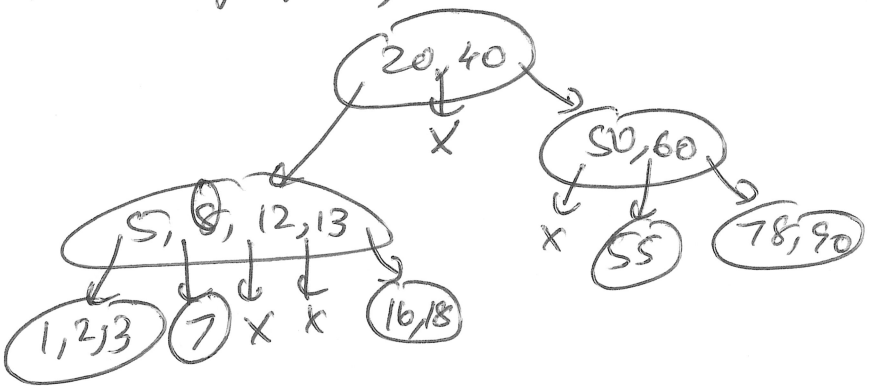
COP 3503 1/25/2024

B-Trees

↳ instead on 2 children ⇒ more but still keep search tree property

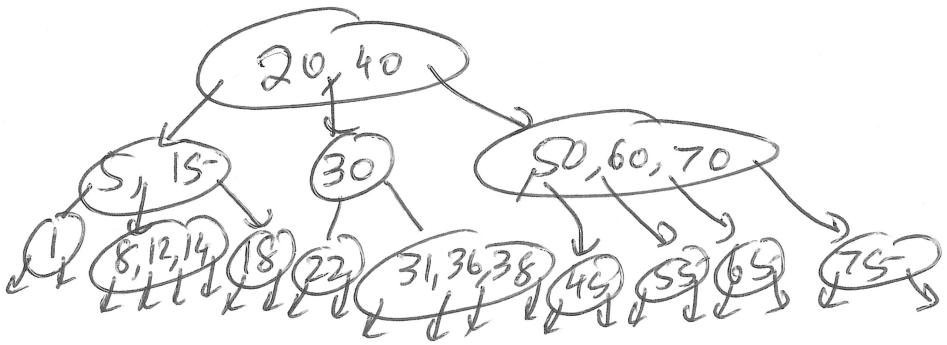


2-4 Tree (specific type of B Tree)

(1) every node has in between 2 and 4 children (each node stores in between 1 and 3 values)

(2) External nodes don't store values but are sort of like null links in a BST. All external nodes are on the same level of the tree. (All leaf nodes are on the same level)

$h = 2$



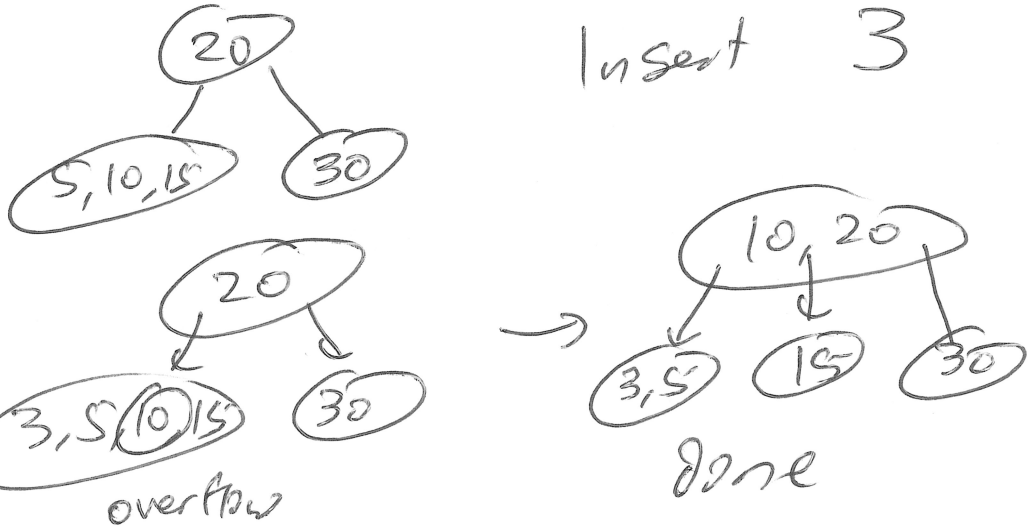
For height h, the min # of nodes/values is $2^{h+1} - 1$.

$\Longrightarrow h = O(\lg n)$, n = num nodes

Difficulty: Adheres to these rules after insert or delete.

Violates Property

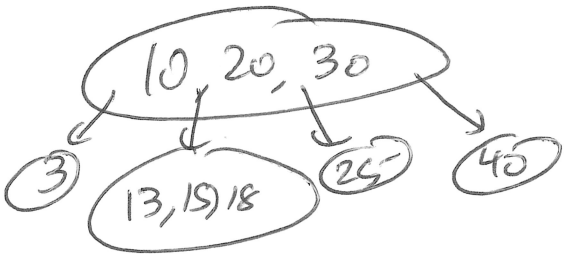
Rule: Node overflow on insert then "push" the 3rd value upto the appropriate parent. If the node root, make the 3rd value the new root.

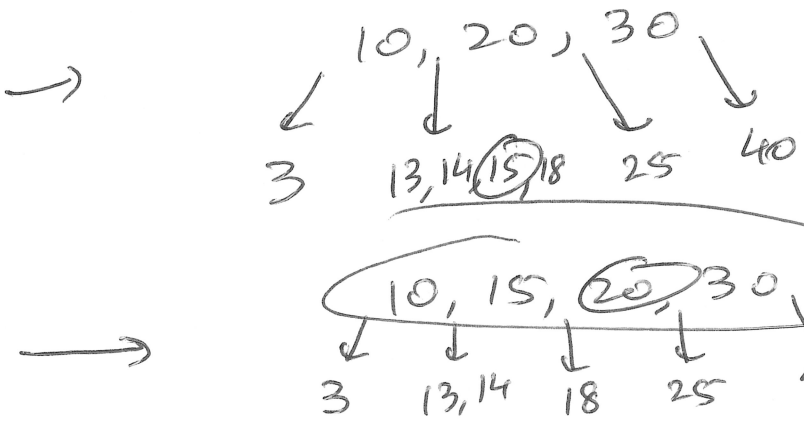


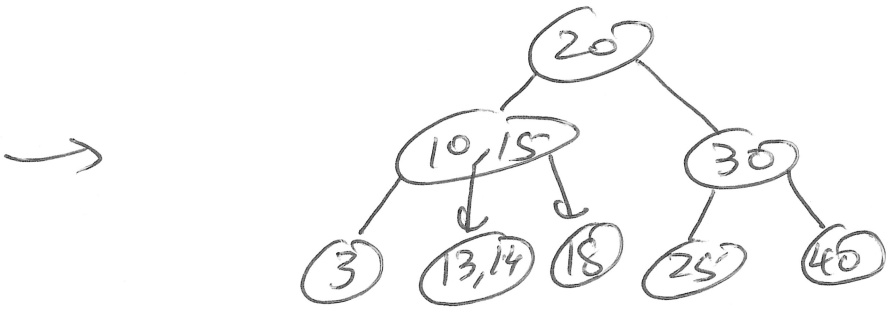
Insert 3

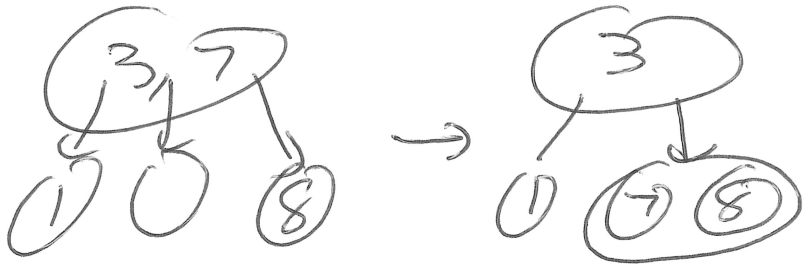
sometimes that parent overflow so repeat...

Insert 14


10, 20, 30
3
13, 19, 18
25
40


10, 20, 30
3
13, 14, 15, 18
25
40
10, 15, 20, 30
3
13, 14
18
25
40


20
10, 15
30
3
13, 14
18
25
40



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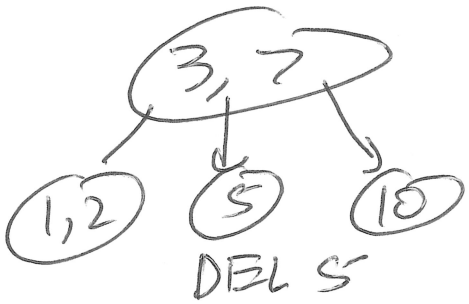
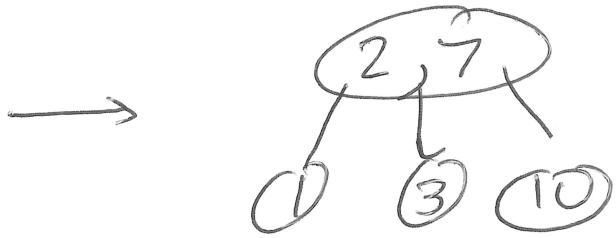
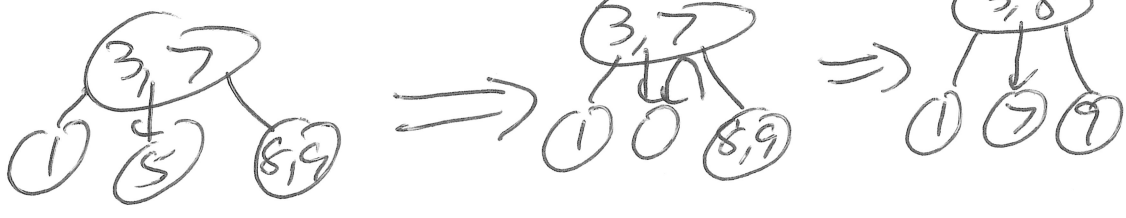
transfer operation



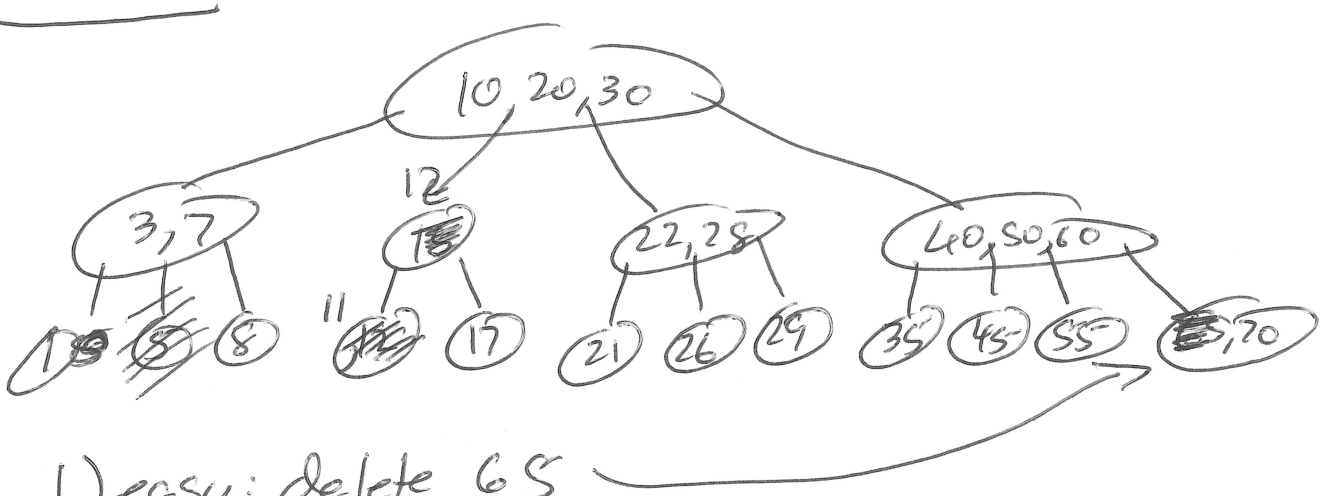
If del causes empty node, first look left + right. See if either has > 1 value. If either does we can a transfer operation



Alt Del 5



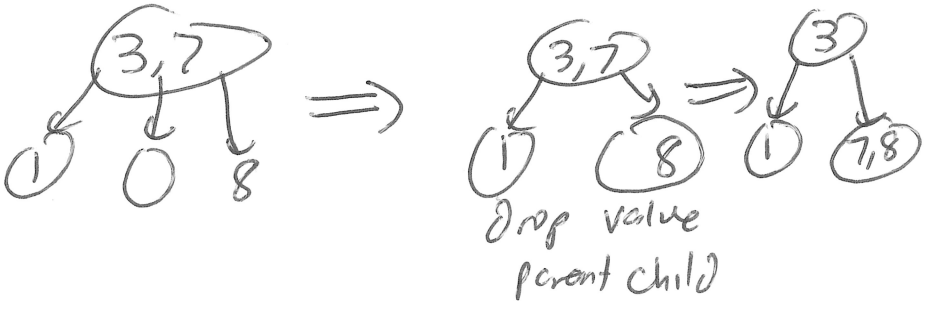
Delete



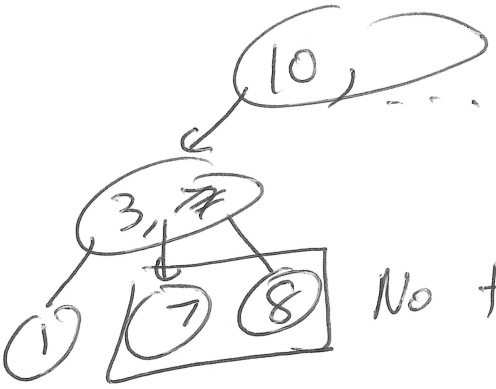
1) easy: delete 65
   bottom level, ~~no other~~ at least 2 values in node

2) still relatively easy
   - delete 15 (not on bottom
   there will be a value on the bottom level that is the next neighbor (either < or >) this value to delete
   Replace deleted value w/ nearest neighbor
   Then remove that nearest neighbor

3) hard: leaf node w/ only 1 value
   DELETE 5 (up top)
   ⟹ 1 fewer children (too many parents)
   Drop a parent into a child

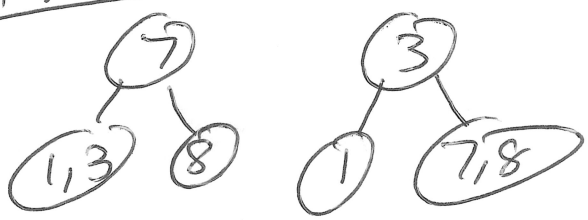


Delete 5



No transfer possible

alt poss



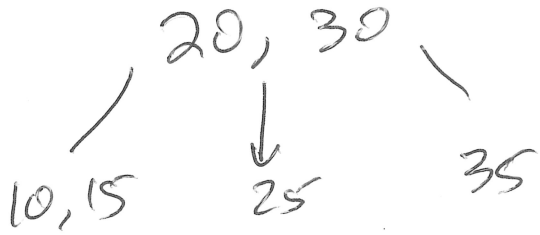
drop value parent into empty child, free empty child w/ appropriate neighbor

Now done!

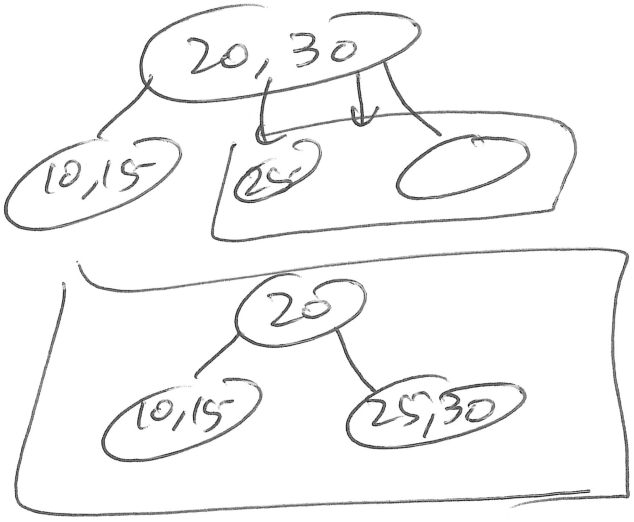
Worst case → drop only node parent into the child, leaving it empty!

↳ recursively deal w/ this empty node

(a) (look to siblings (adjacent) see if they have > 1 value)

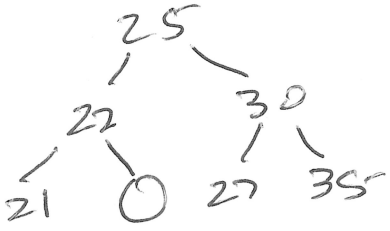


del 35

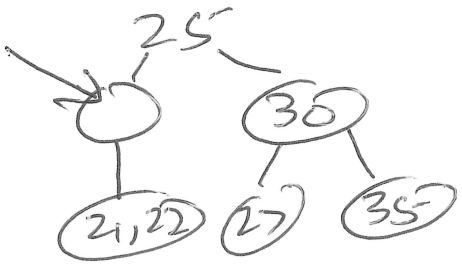


Drop 30
fuse 25, 30

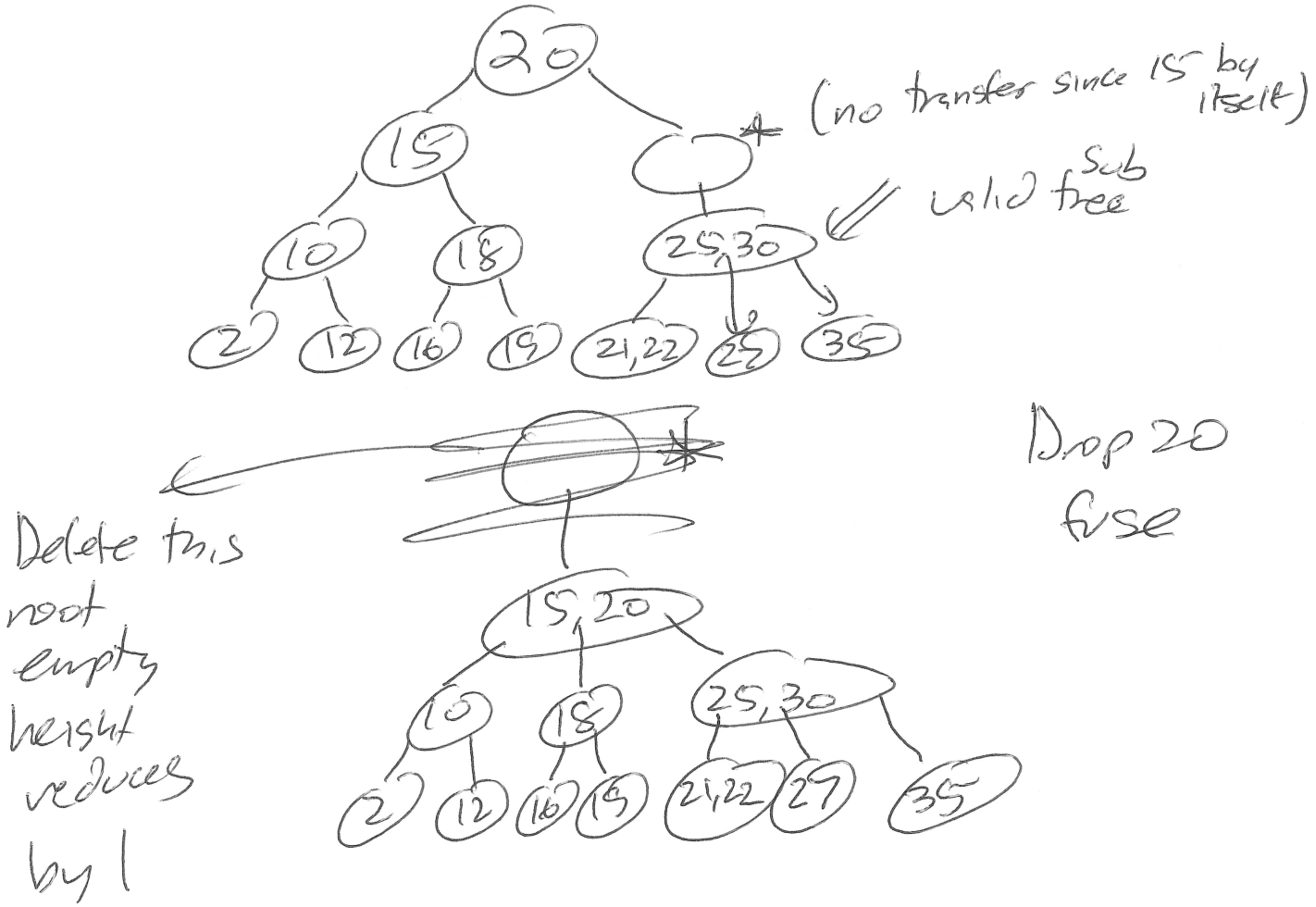
Del 24

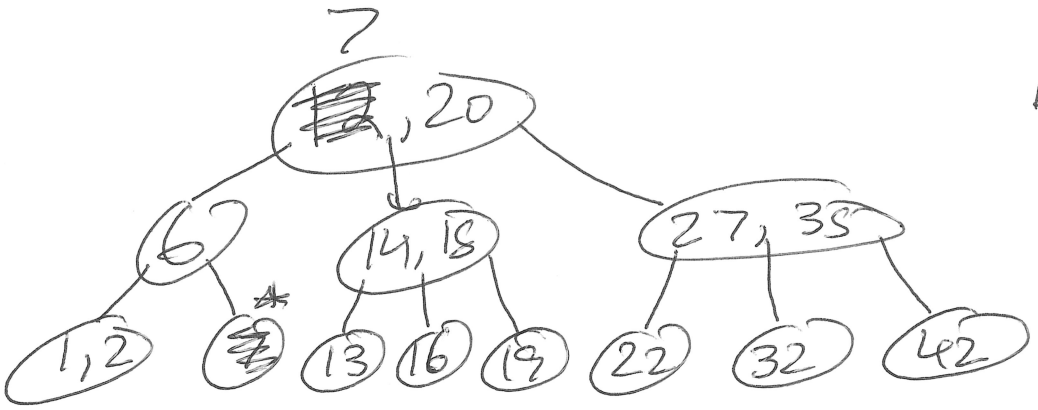


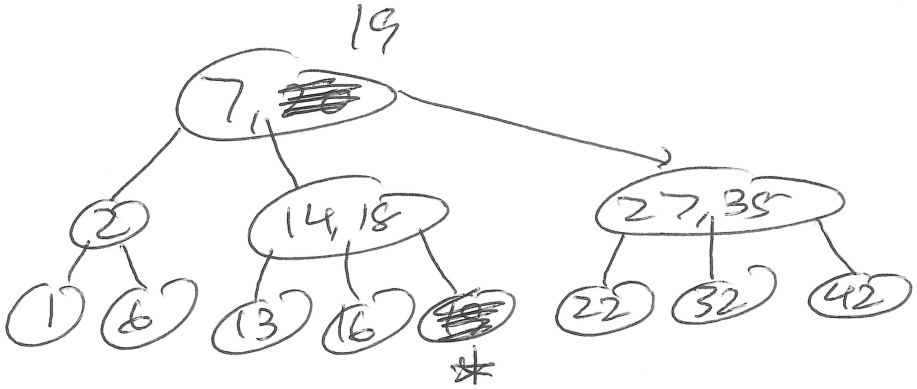
Drop 22
fuse

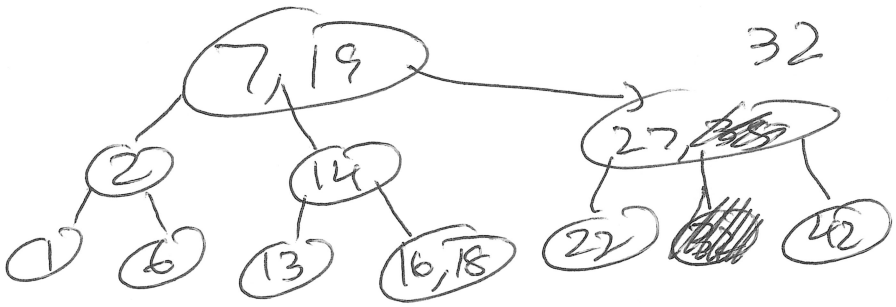


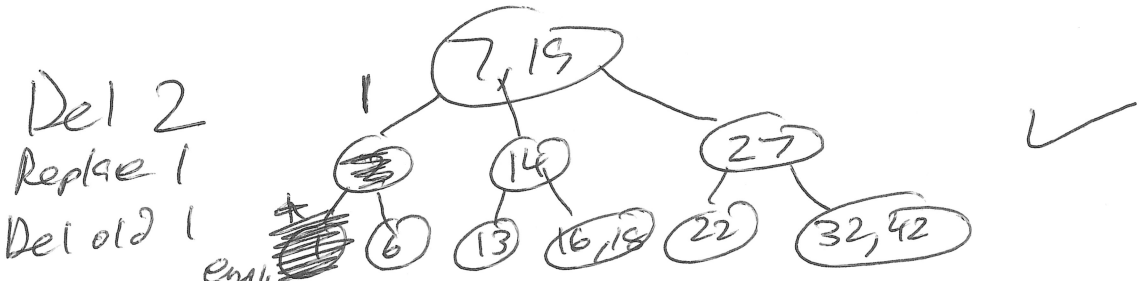
(sibling only has 30 can't borrow

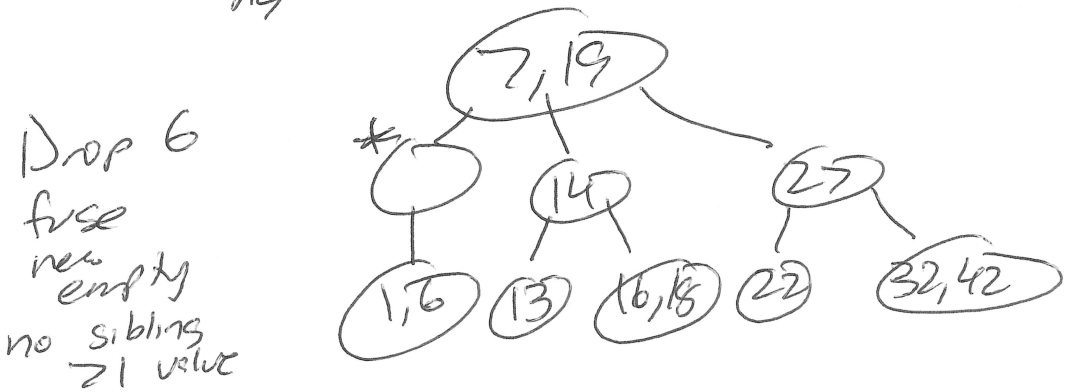

20
15
10
18
25,30
2
12
16
19
21,22
27
35
(no transfer since 15 by itself)
Sub
valid tree
Drop 20
fuse
Delete this
root
empty
height
reduces
by 1
15,20
10
18
25,30
2
12
16
19
21,22
27
35


7
Delete
12
Replace
12 w/7
Del old 7


19
Del 20
Replace
20 w/19
Del old 19


32
Del
35
Replace
w/32
Del old
32


Del 2
Replace 1
Del old 1
empty


Drop 6
fuse
new empty
no sibling
>1 value

Drop 7
fuse 14
reattach kids