

$$\lceil \frac{d-1}{2} \rceil = \lceil \frac{3}{2} \rceil = 2$$

(leaf Node)  
(元素)

$$\lceil \frac{d}{2} \rceil = \lceil \frac{4}{2} \rceil = 2$$

(innerNode)  
指针

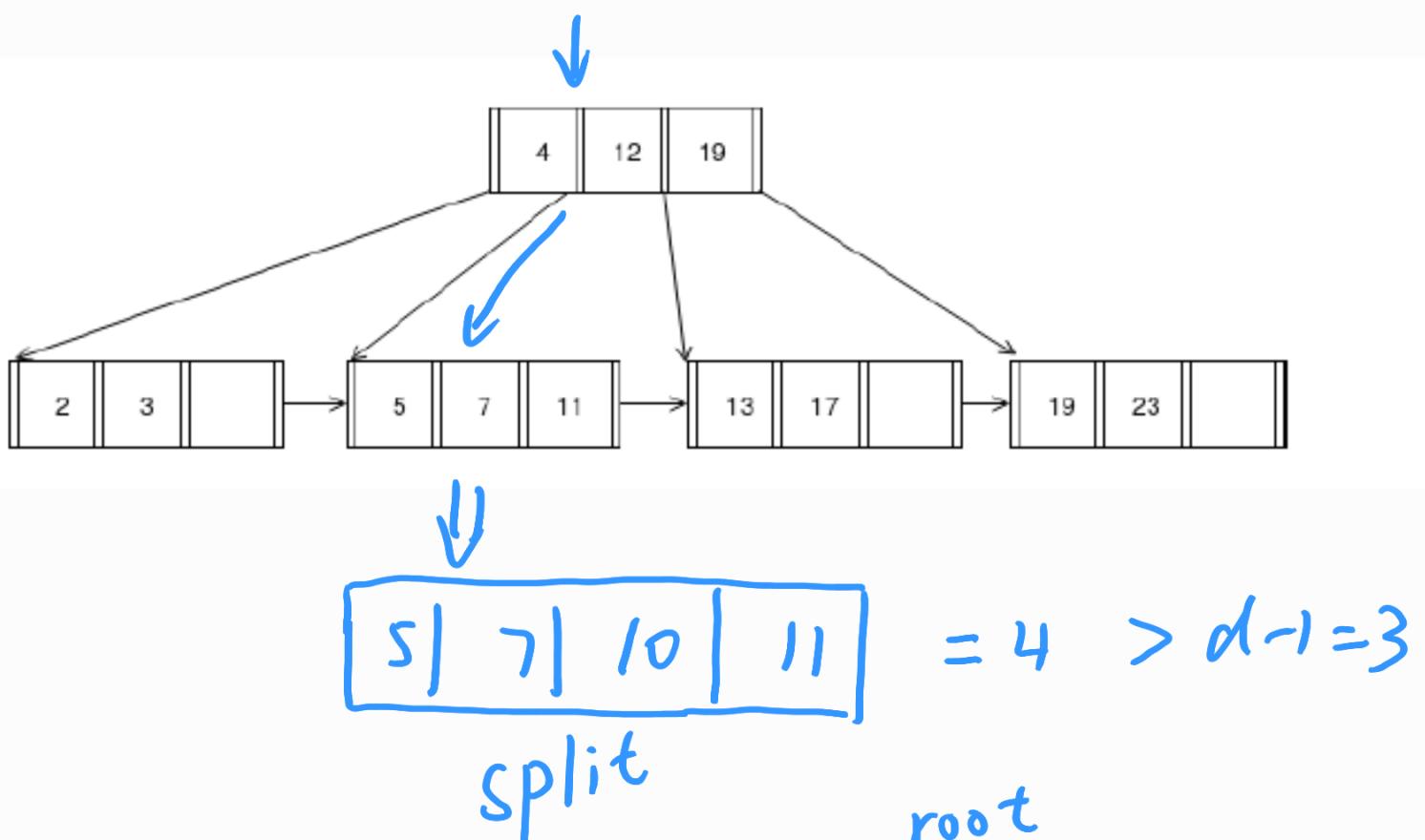
$d = 4$  :  $B+$  树一个节点出去的最大路径数.

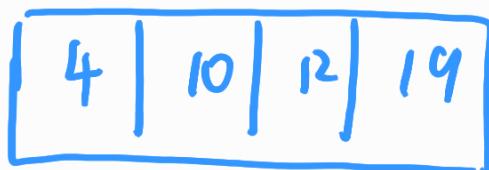
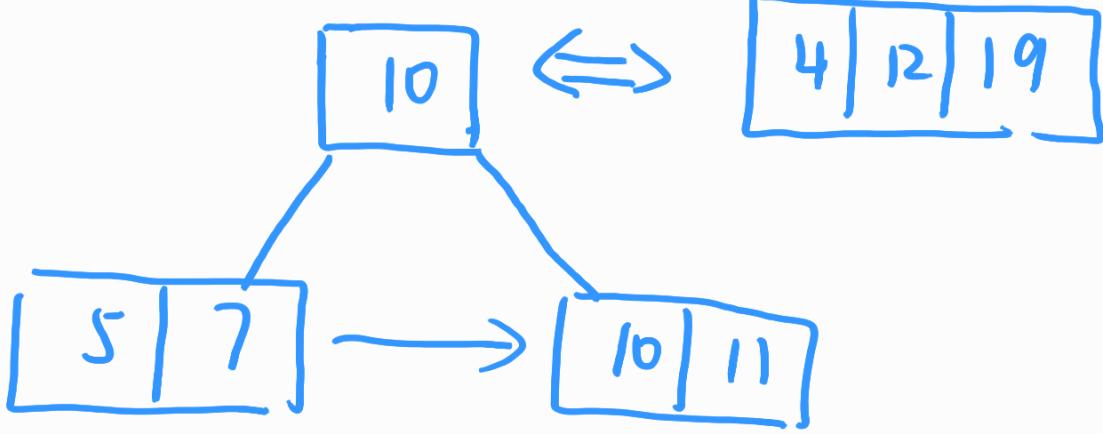
$\Rightarrow$  节点 key 最多  $d-1=3$  个

InnerNode = 所有非 Leaf Node

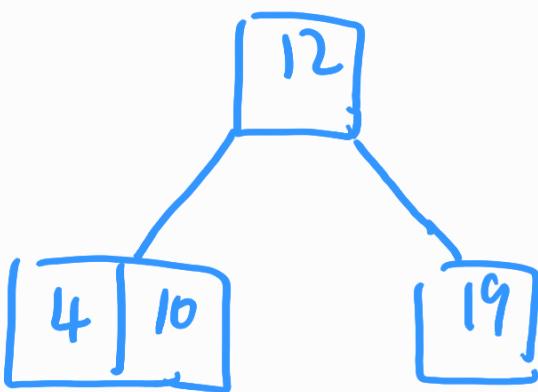
(a)

Insert 10 into  $B+$  tree.

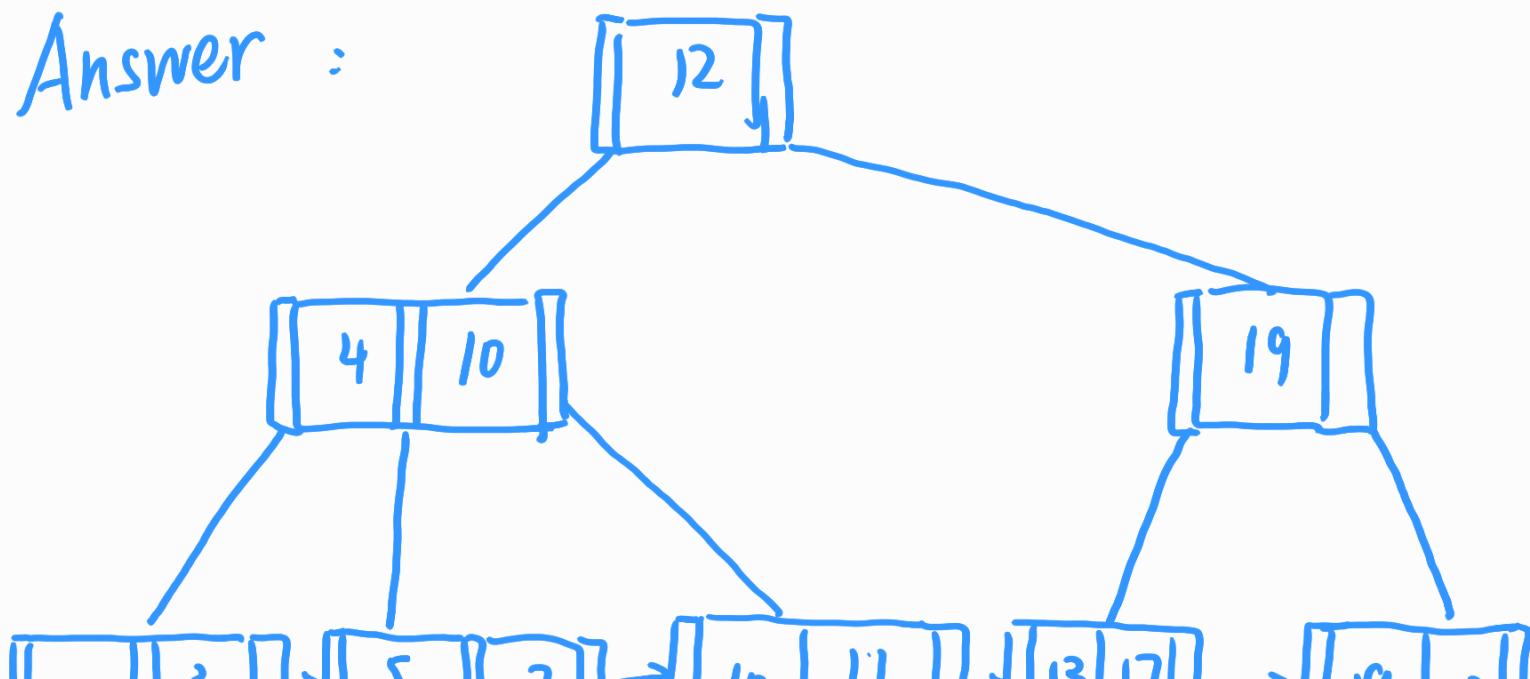


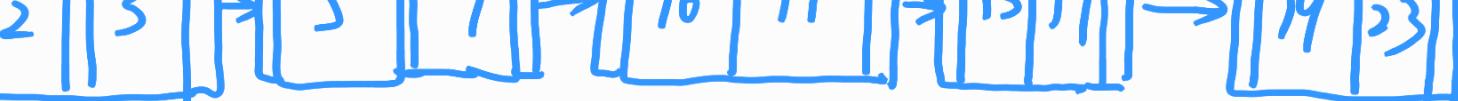


split



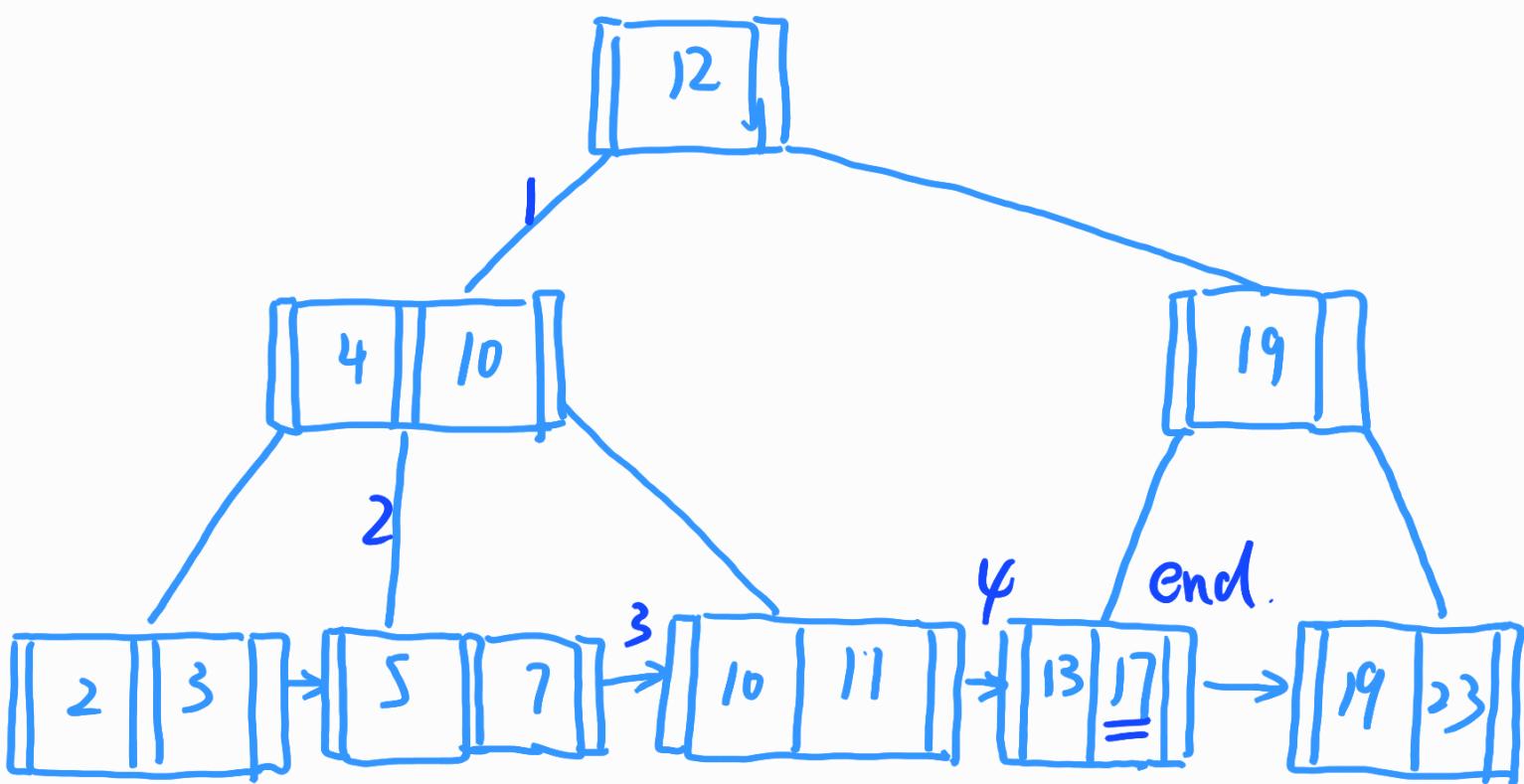
Answer :





(b)

为了找到 5~15 范围的 key,  
追踪的指针数



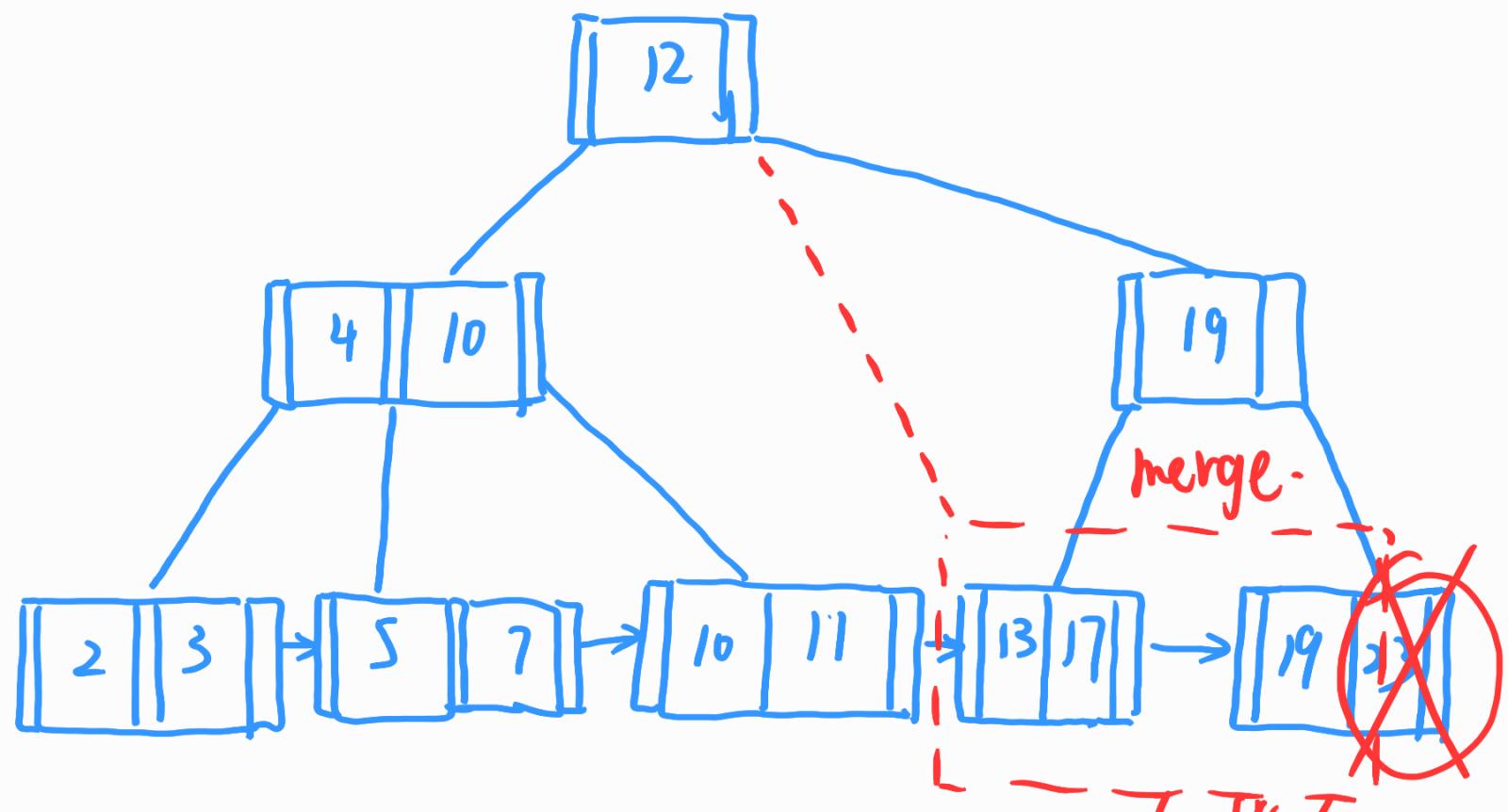
Answer = 4

(c) delete 23

underflow : 下溢, 节点元素个数小于  
最小值限制

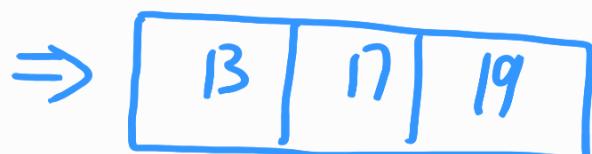
(删除与级)

overflow : 上溢, 节点元素个数  $\geq$  degree, (插入导致)

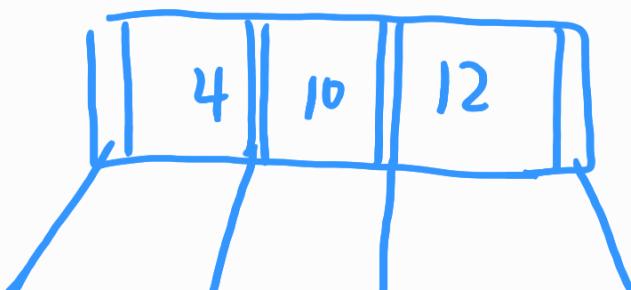


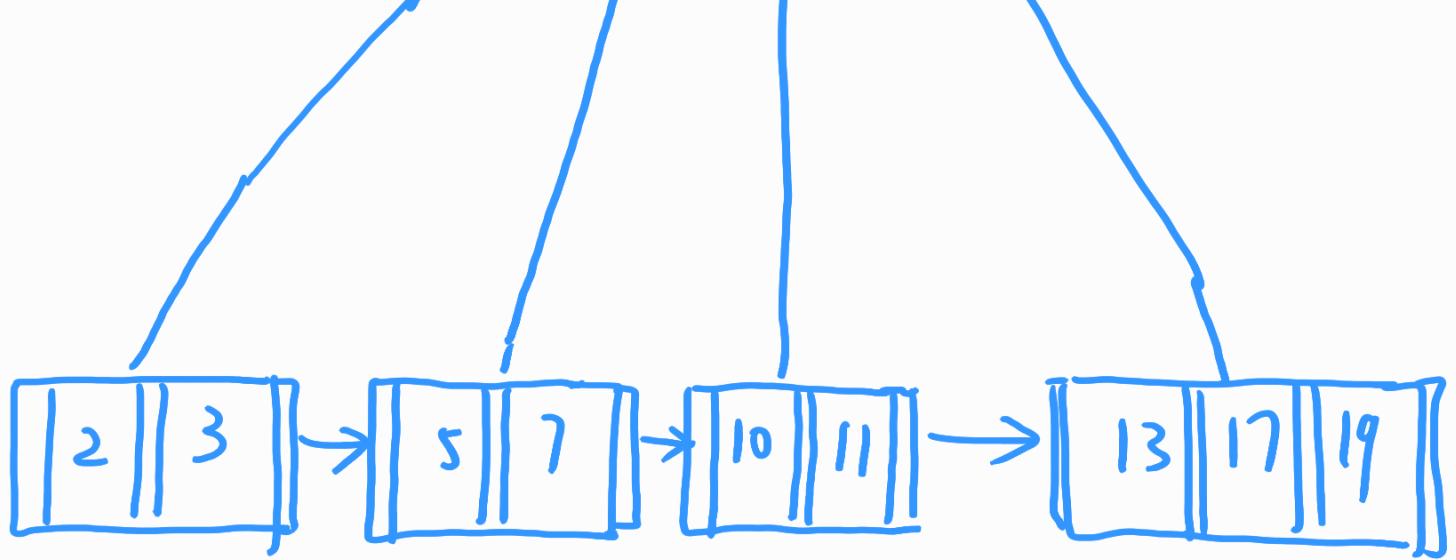
需要 underflow 操作

元素 num = 1 < 2



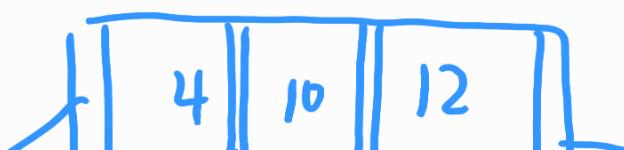
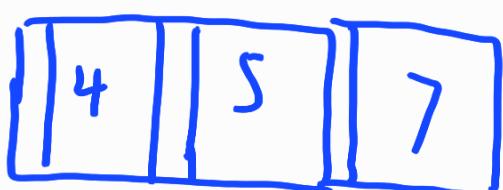
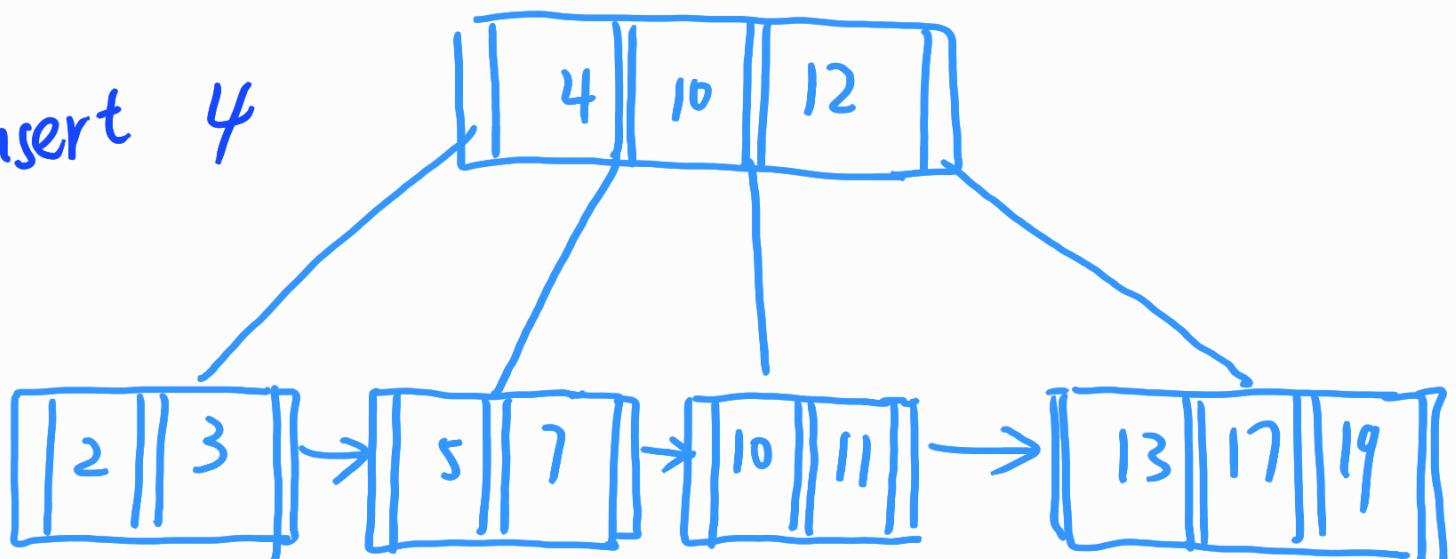
Answer :

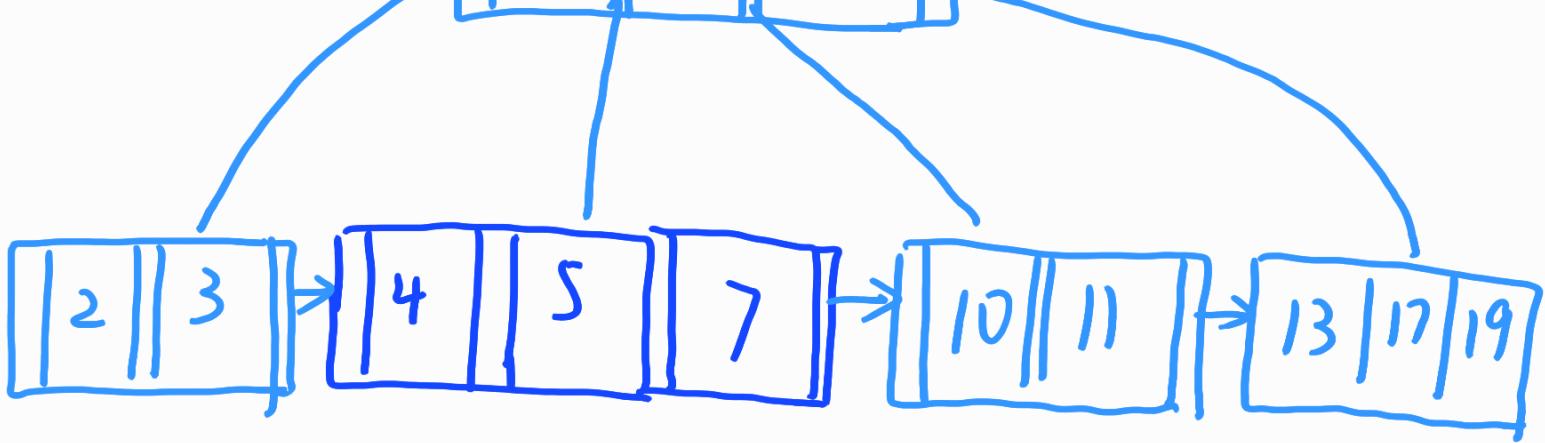




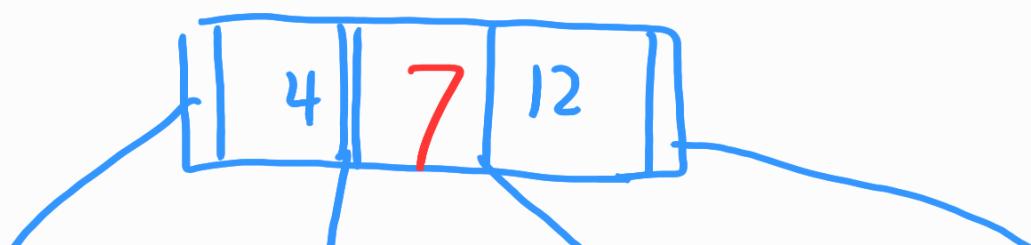
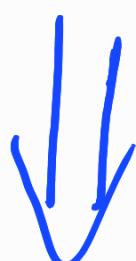
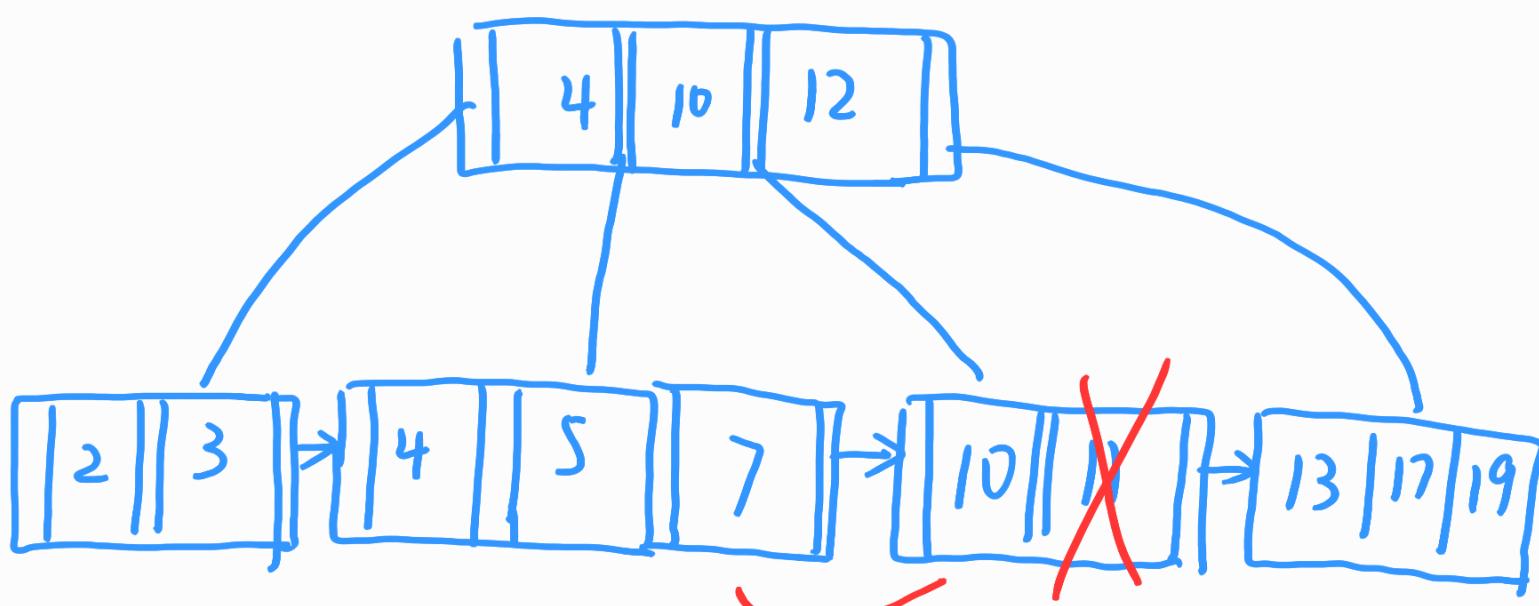
(db: insert 4, delete 11)

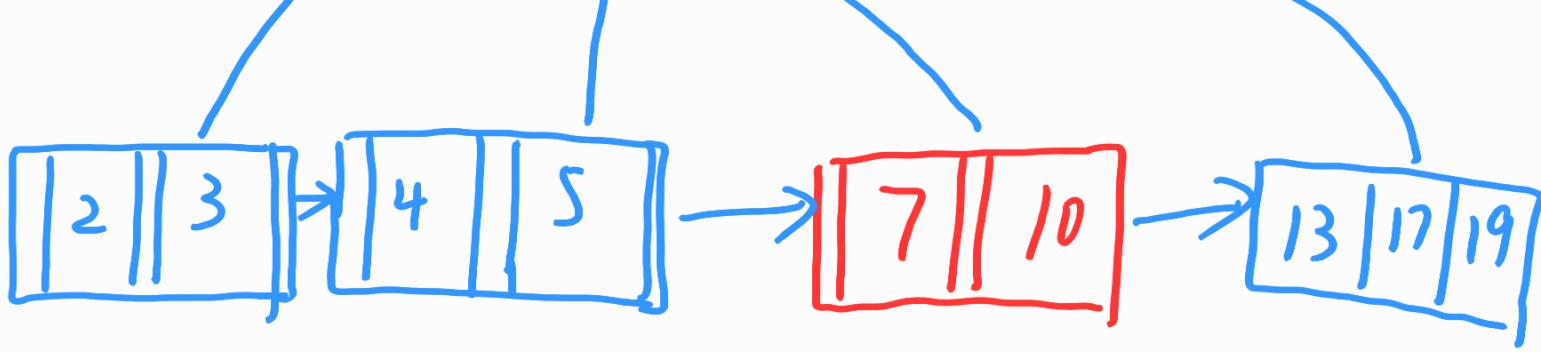
insert 4





delete 11





Answer :

