



2-3 TREE



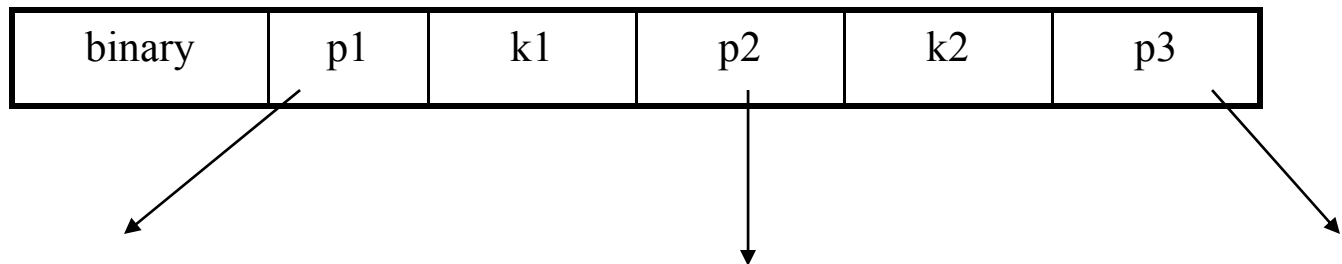
2-3 Tree Definition

- All leaf nodes are at the same level.
- All non leaf nodes are either binary or ternary.
- Binary nodes are like BST nodes with single key k .
- Ternary nodes have two keys k_1 and k_2 and three children pointers p_1 , p_2 , p_3 .
- All keys $< k_1$ reside in sub-tree pointed to by p_1 . All keys $> k_2$ reside in sub-tree pointed to by p_3 . Others reside in the sub-tree pointed to by p_2 . All keys are distinct .



2-3 Tree node

```
typedef struct nt {  
    T      k1, k2;  
    int    binary;  
    struct nt * p1, * p2, * p3;  
} 23treenode;
```





Operations

➤ If h is the height of a 2-3 tree having n nodes,

$$\text{then } 2^h - 1 \leq n \leq 3^h - 1$$

$$\text{Thus, } \log_3(n+1) \leq h \leq \log_2(n+1)$$

Operations:

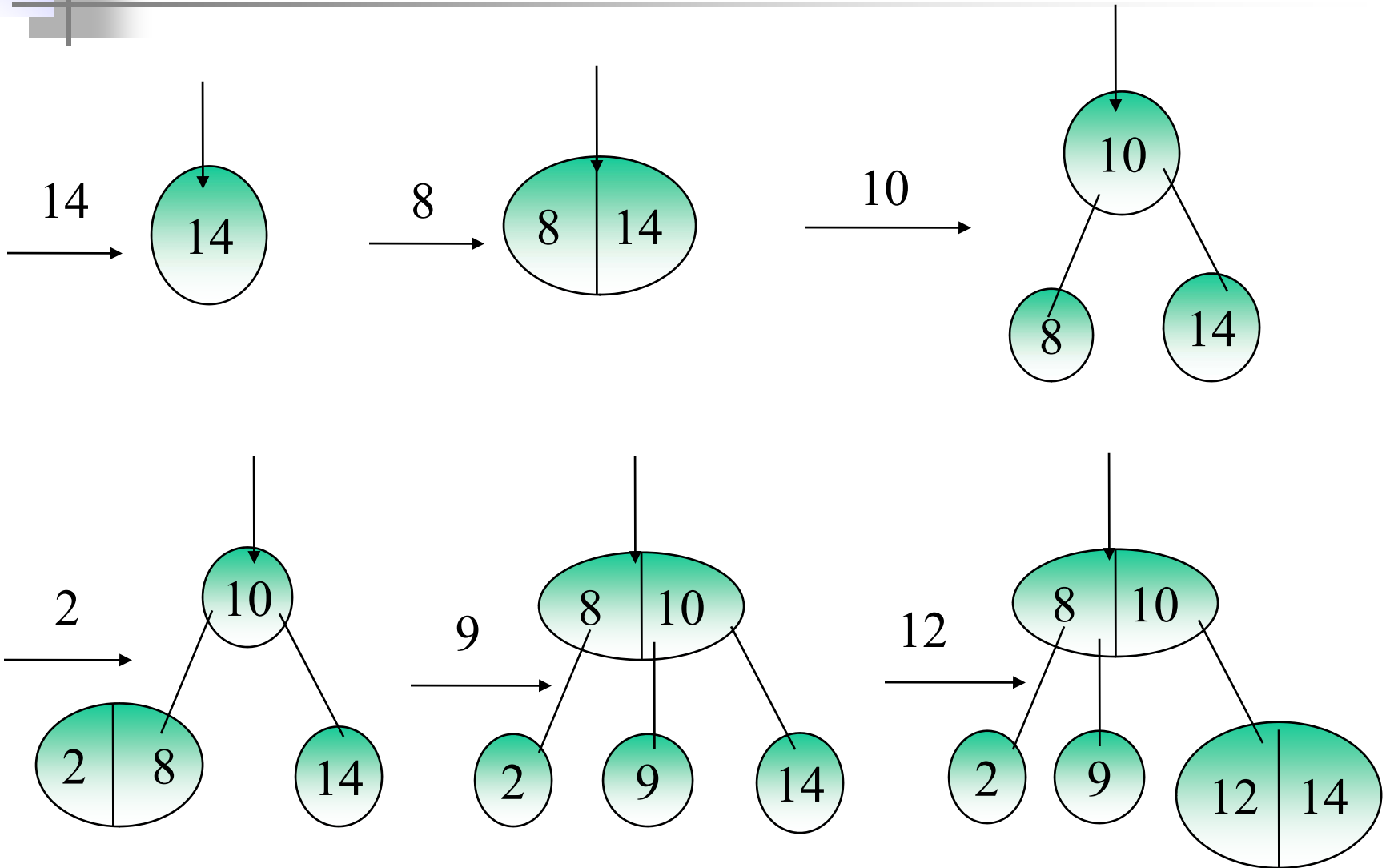
Insert node

Delete node

Search node

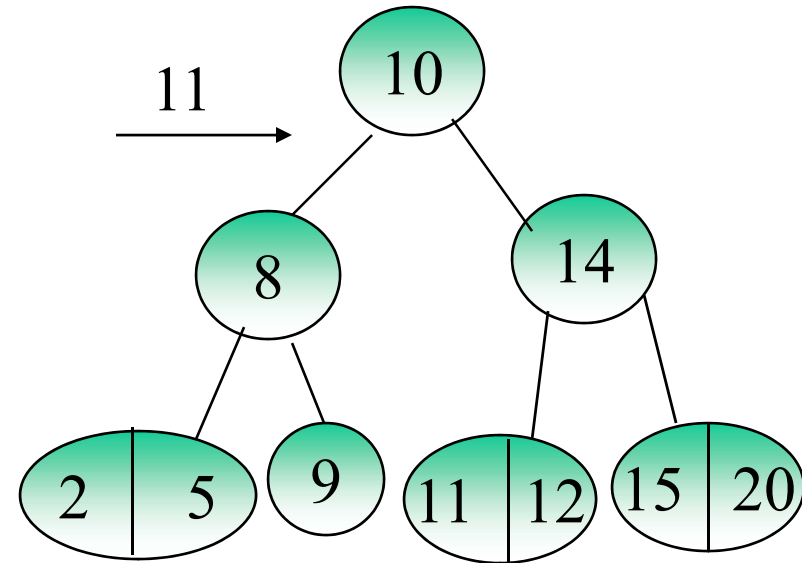
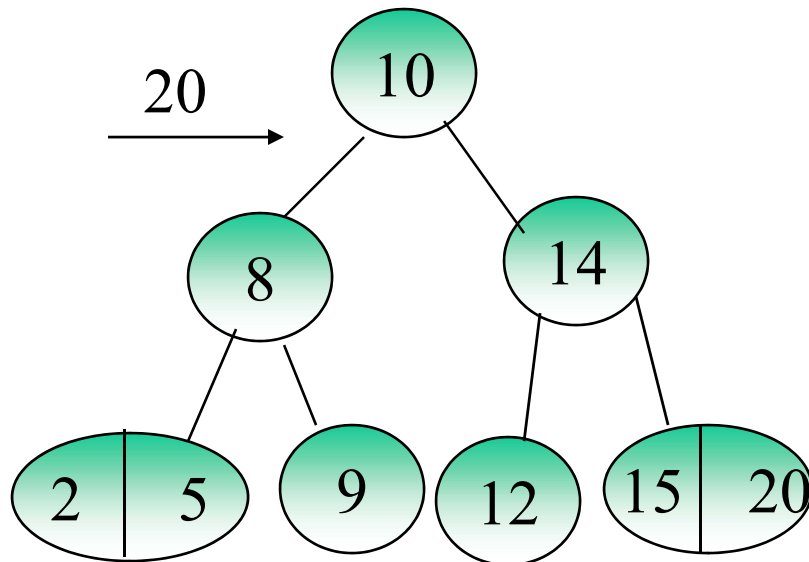
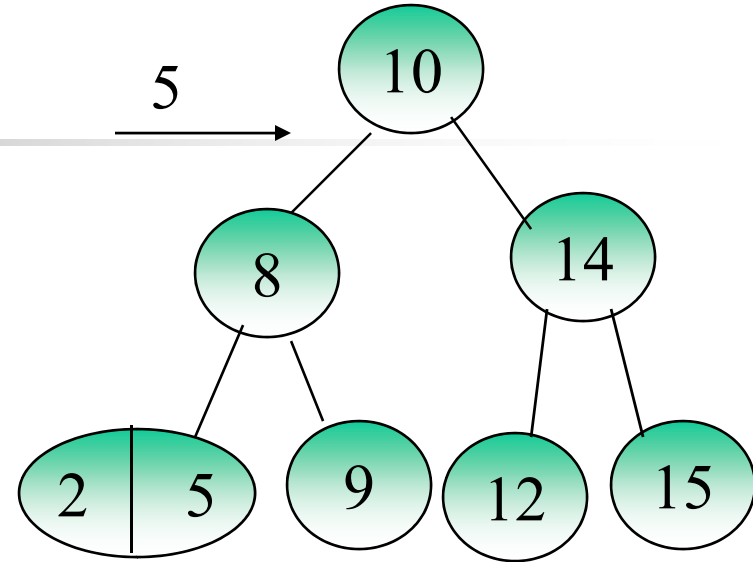
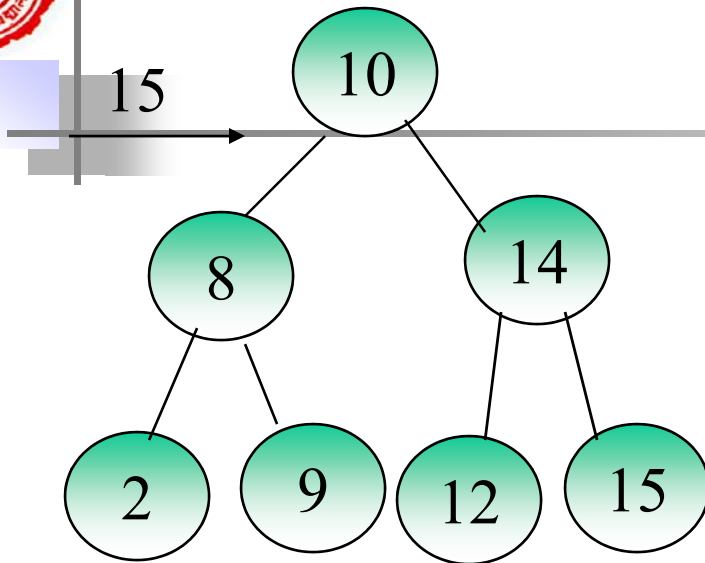


INSERTION EXAMPLES



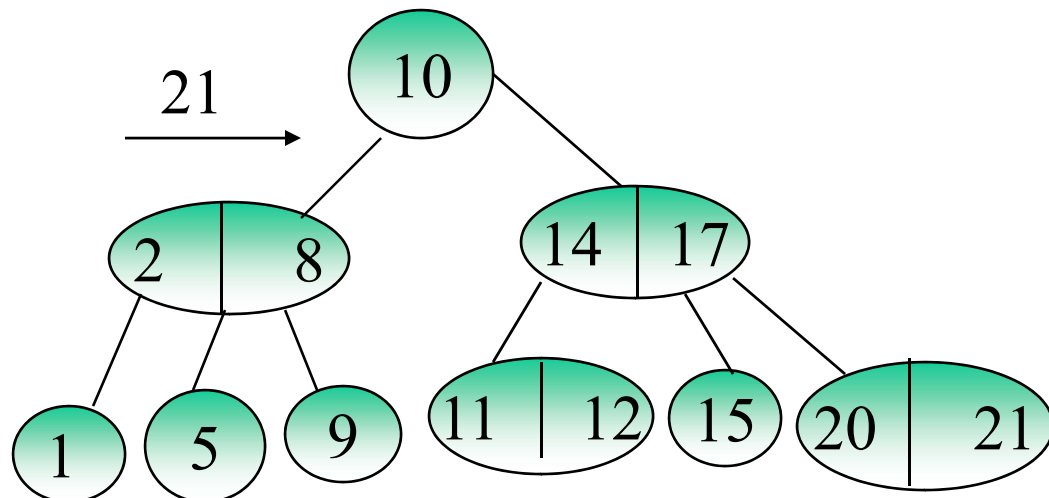
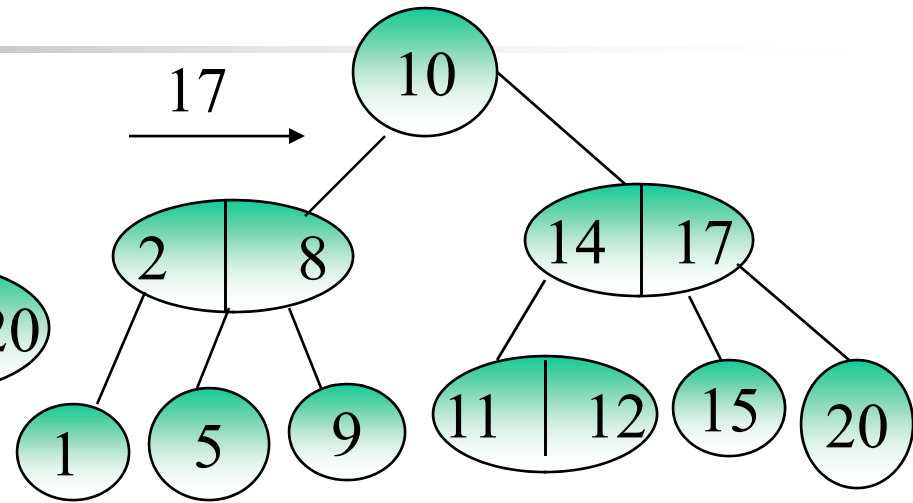
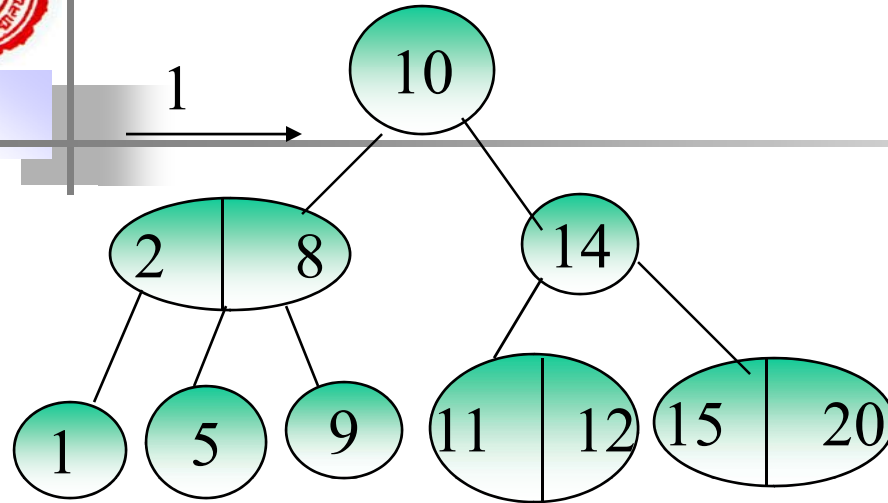


INSERTION EXAMPLES ...



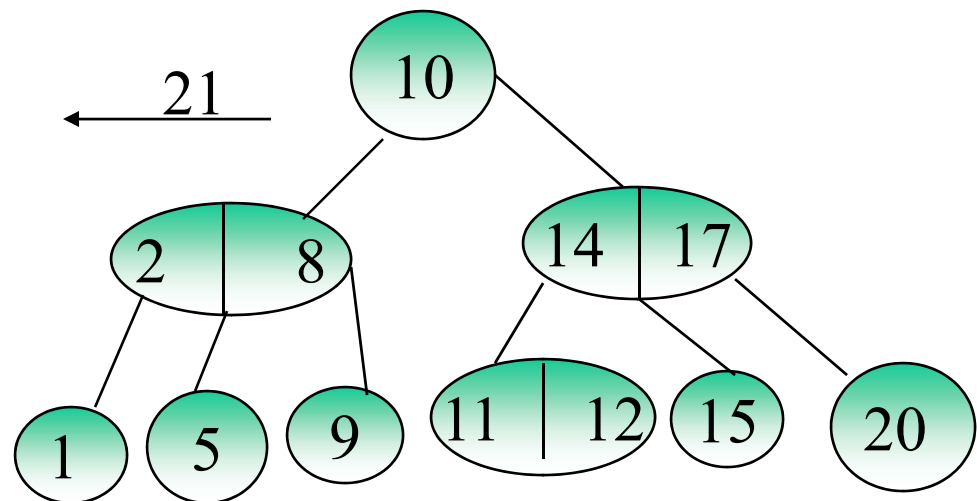
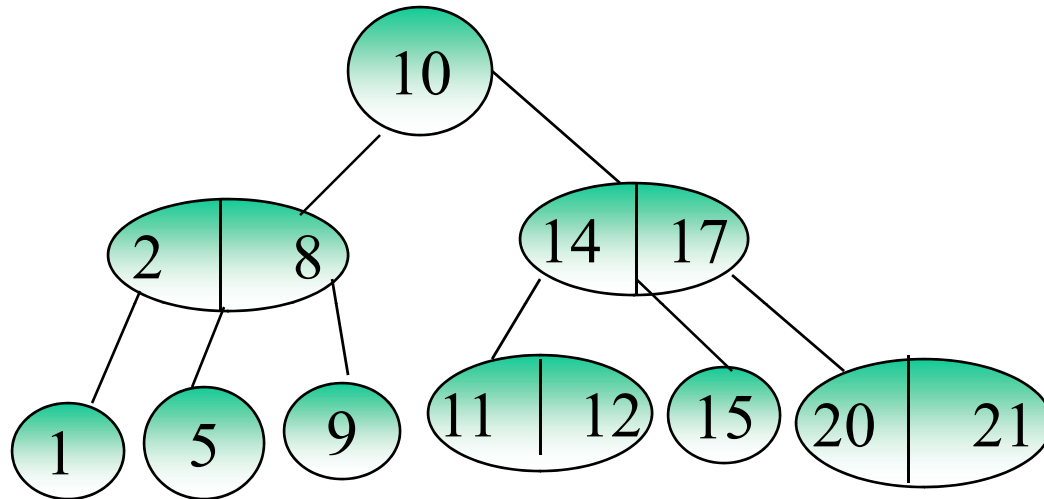


INSERTION EXAMPLES ...



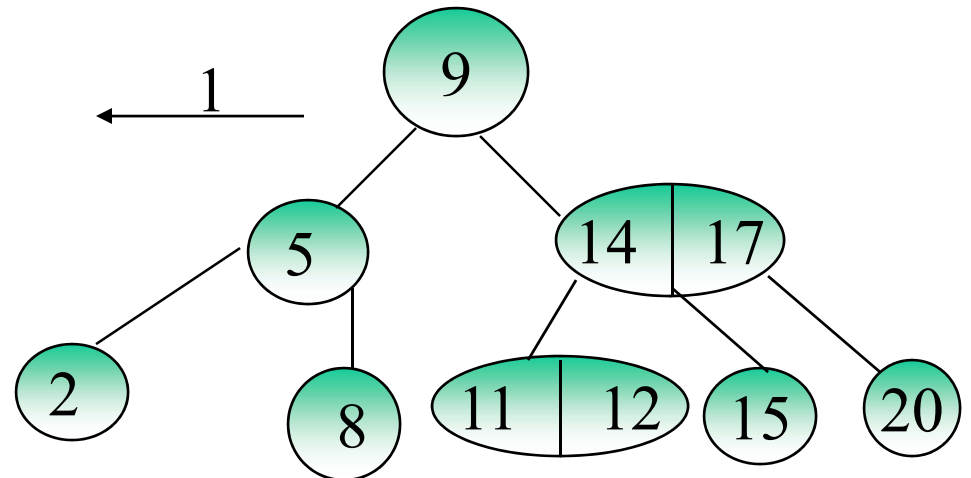
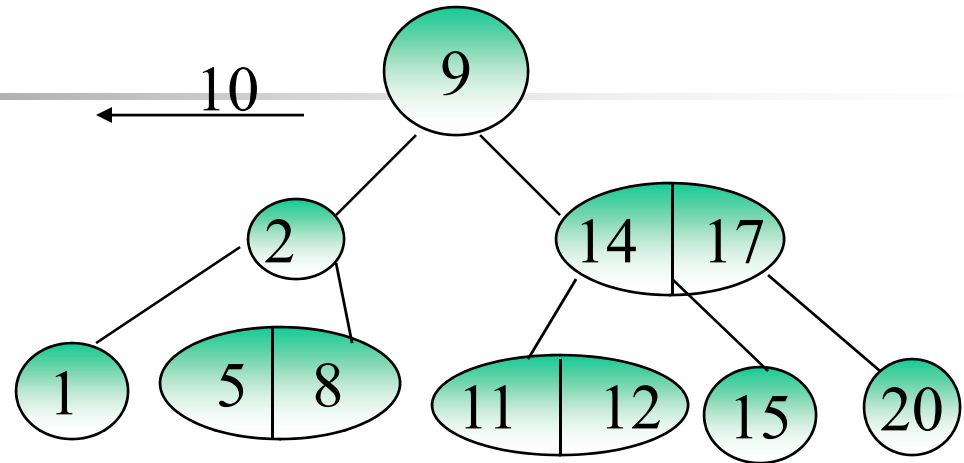


DELETION EXAMPLES



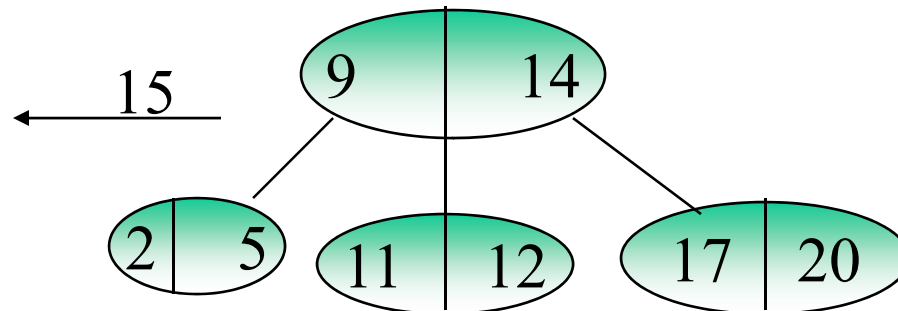
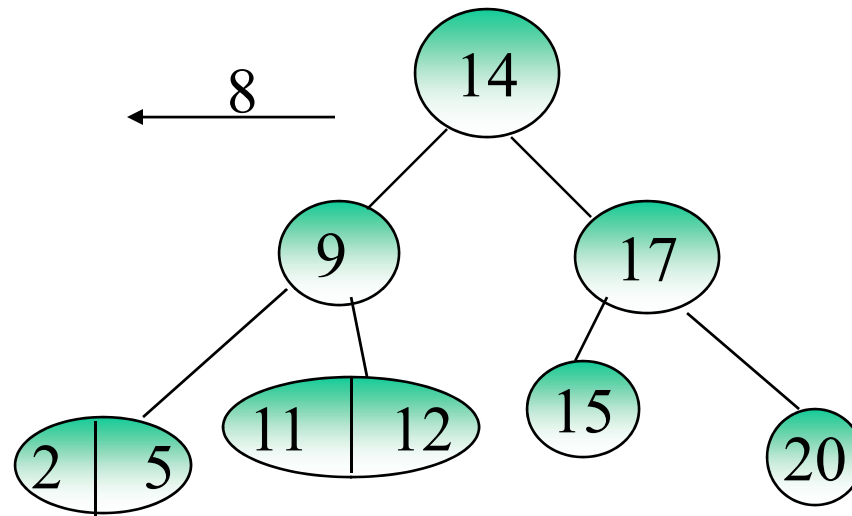


DELETION EXAMPLES ...





DELETION EXAMPLES ...





B TREE



B-Tree Definition

A B-Tree of order d is a tree with following properties:

- Each node (except possibly the root node) contains at most d records and at least $\lfloor d/2 \rfloor$ records.
- The root node can have at most d records and as few as one record.
- An internal node containing k records ($1 \leq k \leq d$) with key values k_1 to k_k , have pointers to $k+1$ subintervals of keys stored in sub-trees.
- A leaf node has empty sub-tree below it. All leaf nodes are at the same level.



B-TREE Node

```
typedef struct btnode {  
    int    k;  
    T      datalist[maxkeyno];  
    struct btnode * ptr[maxkeynode + 1];  
}
```

Height of a B-Tree of order d containing n nodes is given by

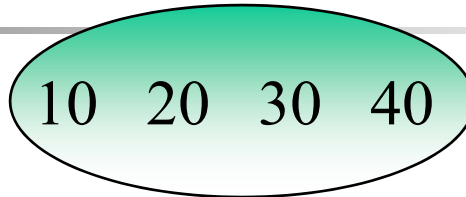
$$\lfloor \log_{\lfloor d/2 \rfloor + 1} (n+1) \rfloor \geq h \geq \lceil \log_{d+1} (n+1) \rceil$$

2-3 tree is a B-Tree of order 2

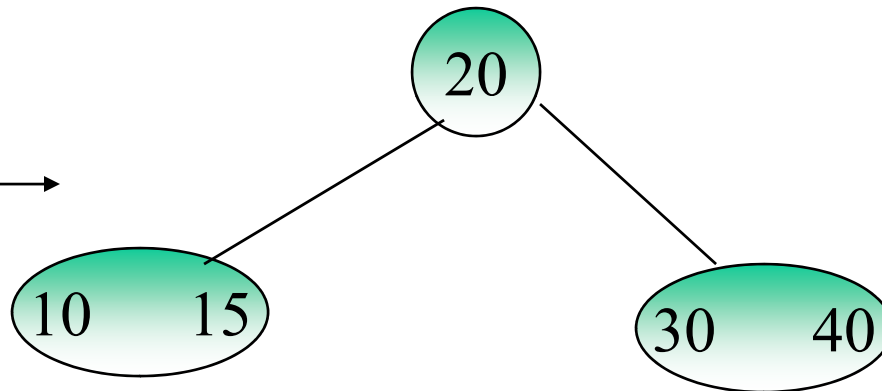


Insertion Examples on a B-Tree of order 4

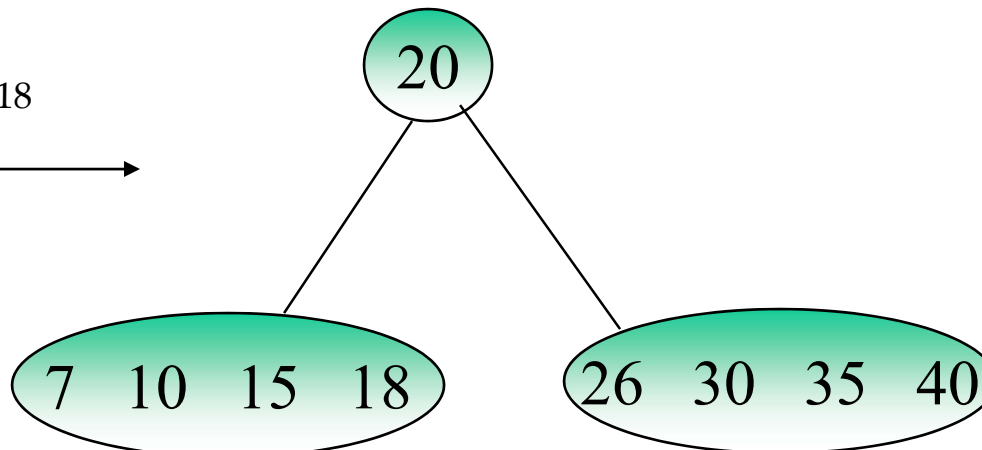
20, 40, 10, 30



15

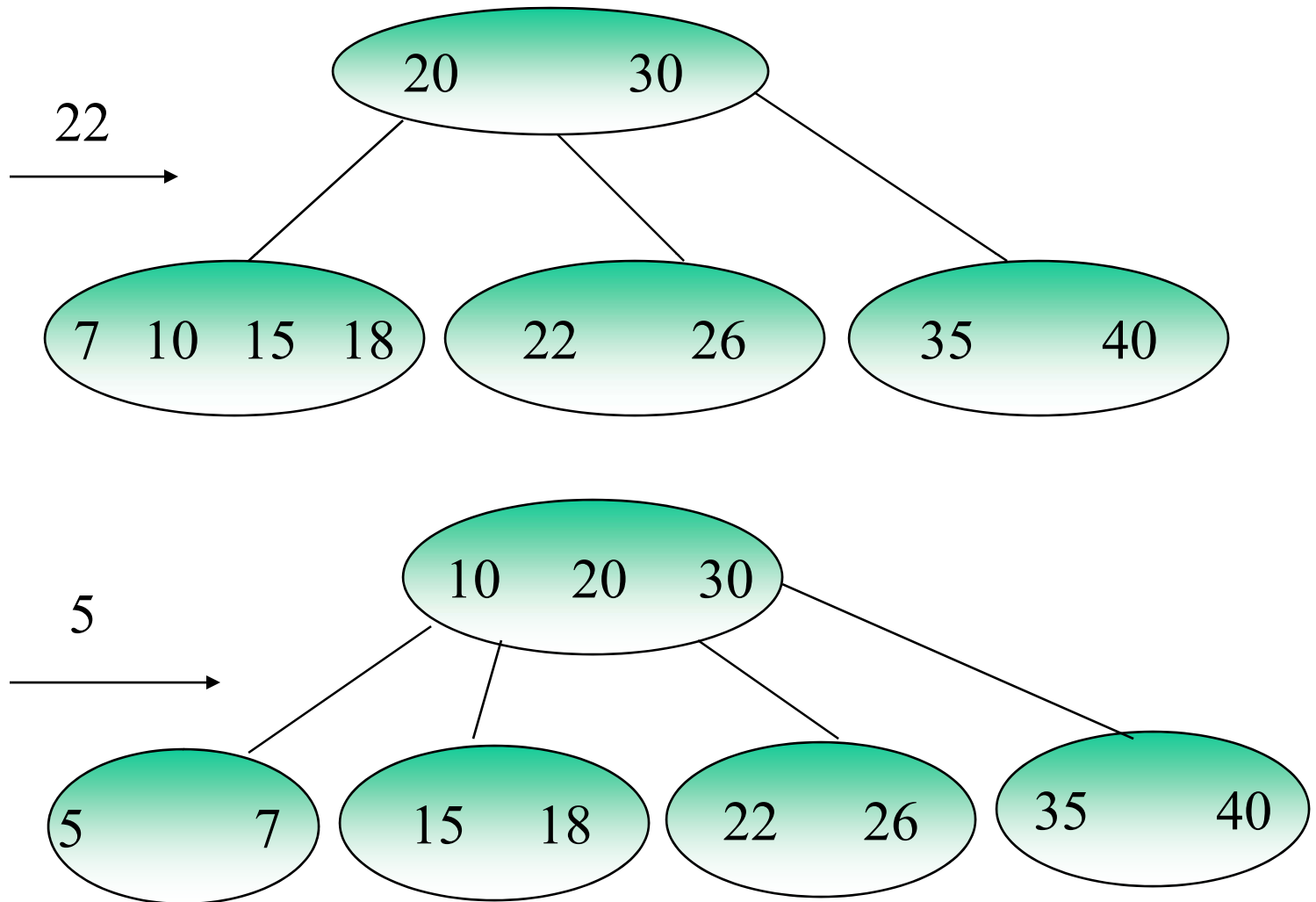


35, 7, 26, 18



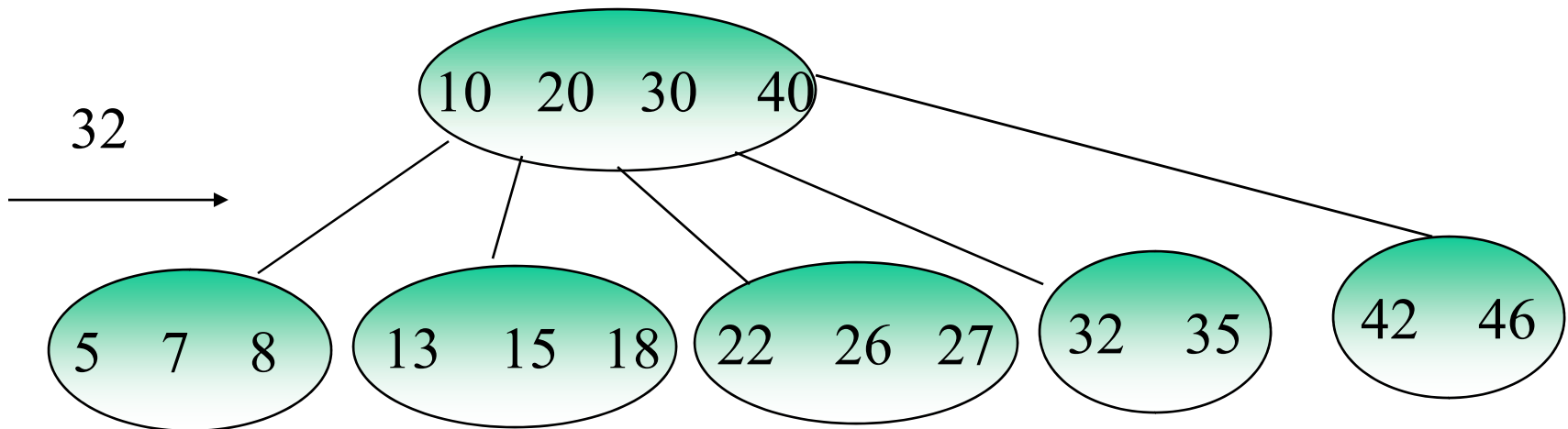
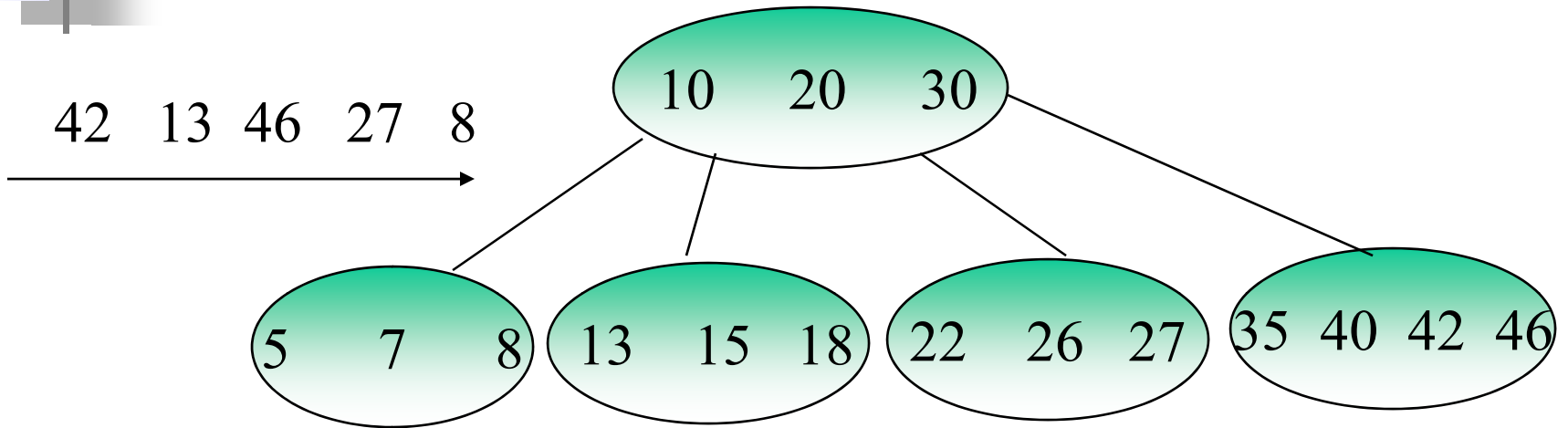


Insertion Examples ...



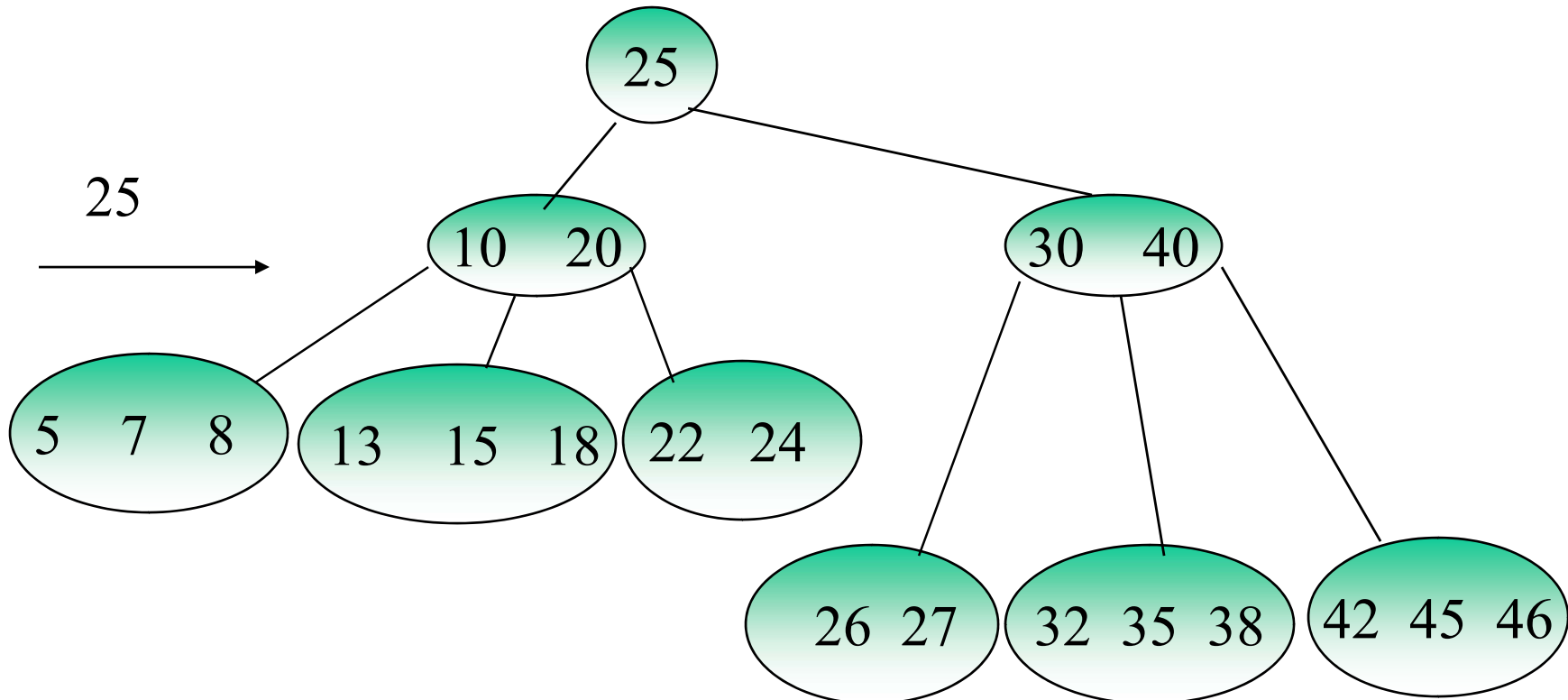
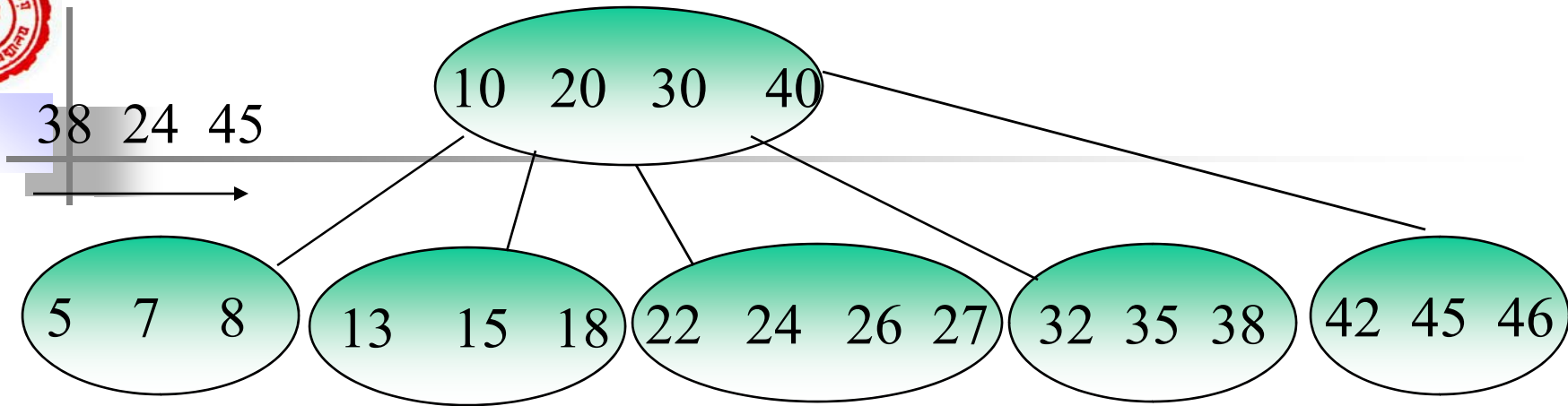


Insertion Examples ...



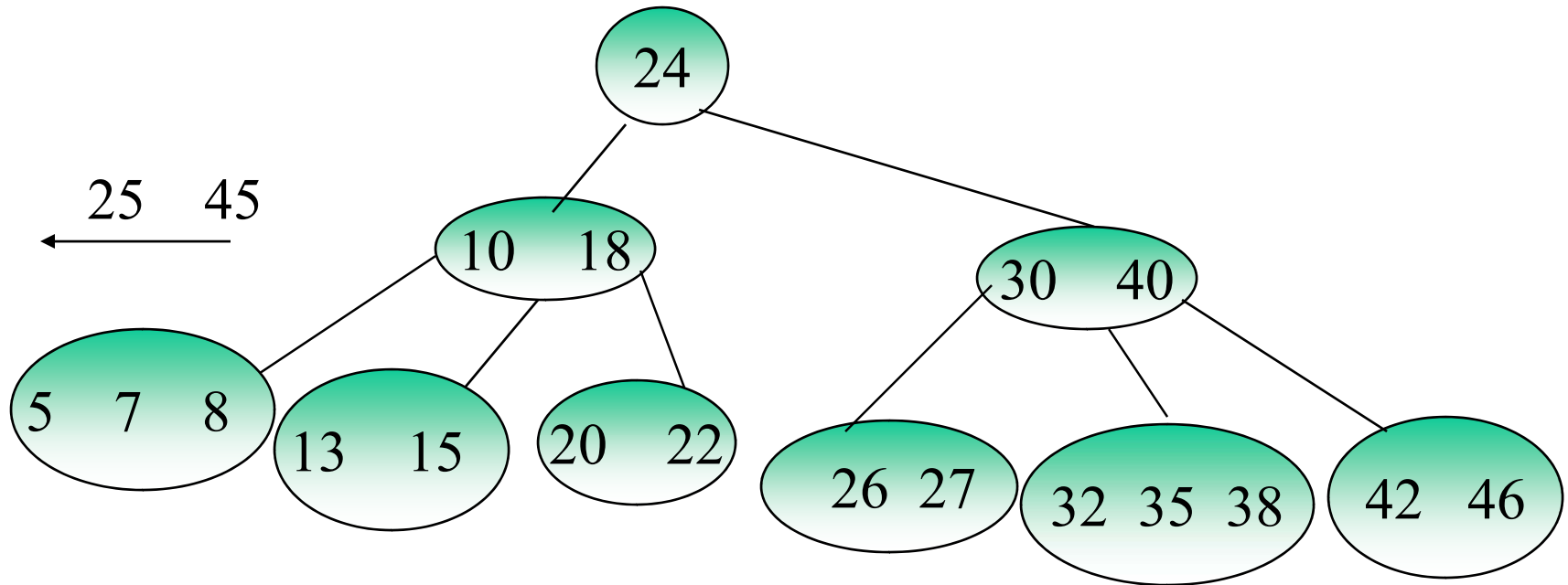


Insertion Examples ...



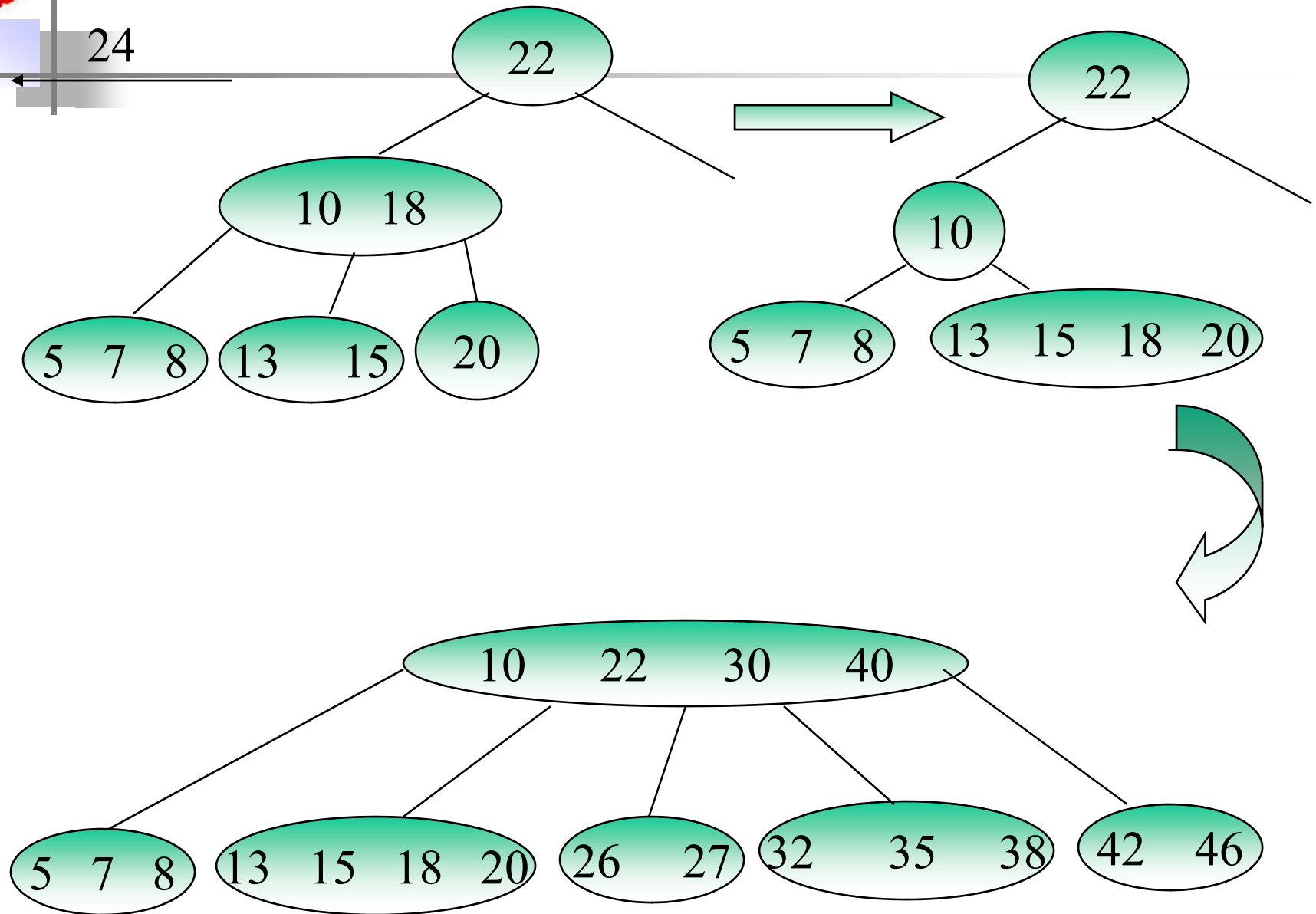


Deletion examples



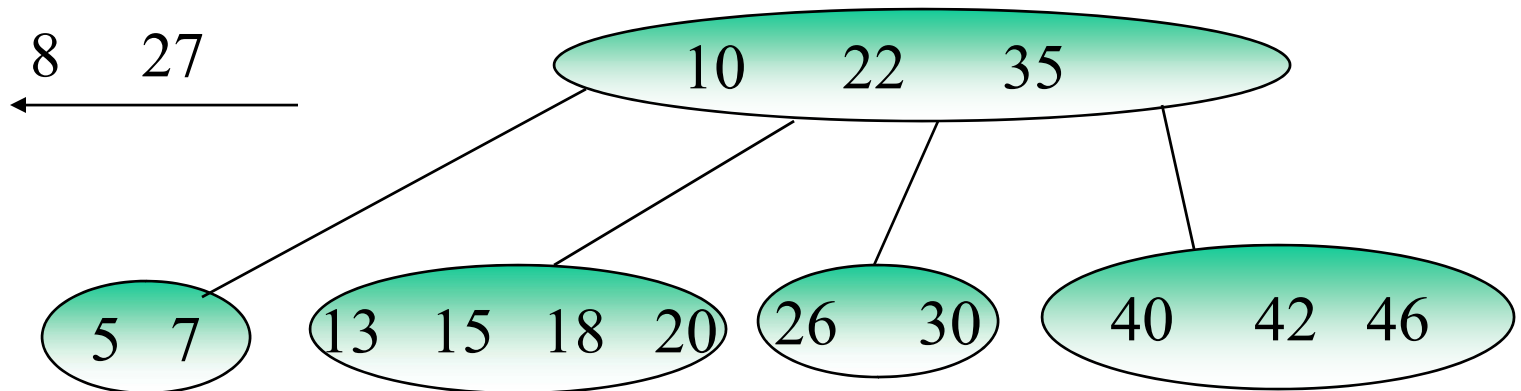
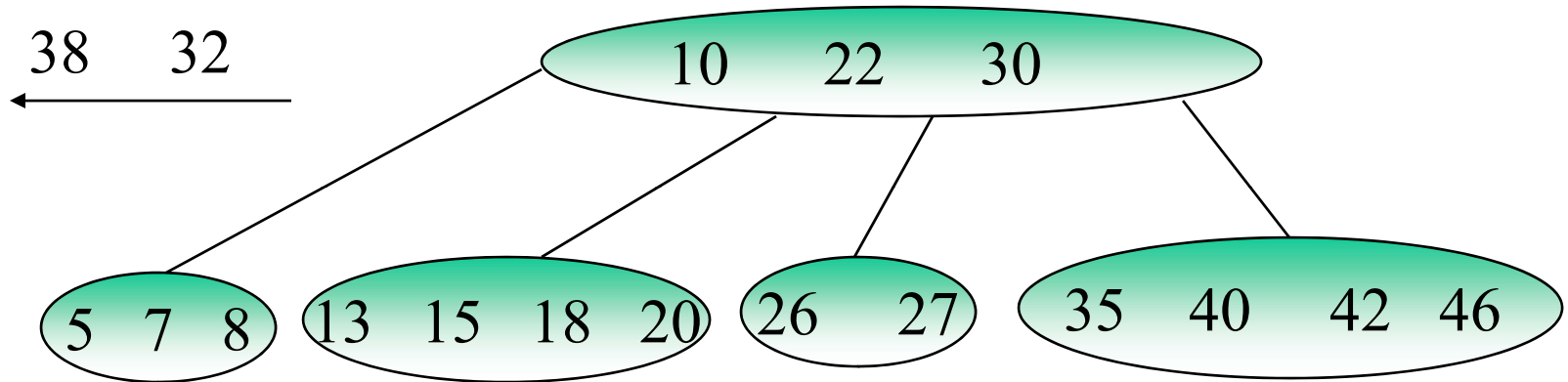


Deletion examples ...



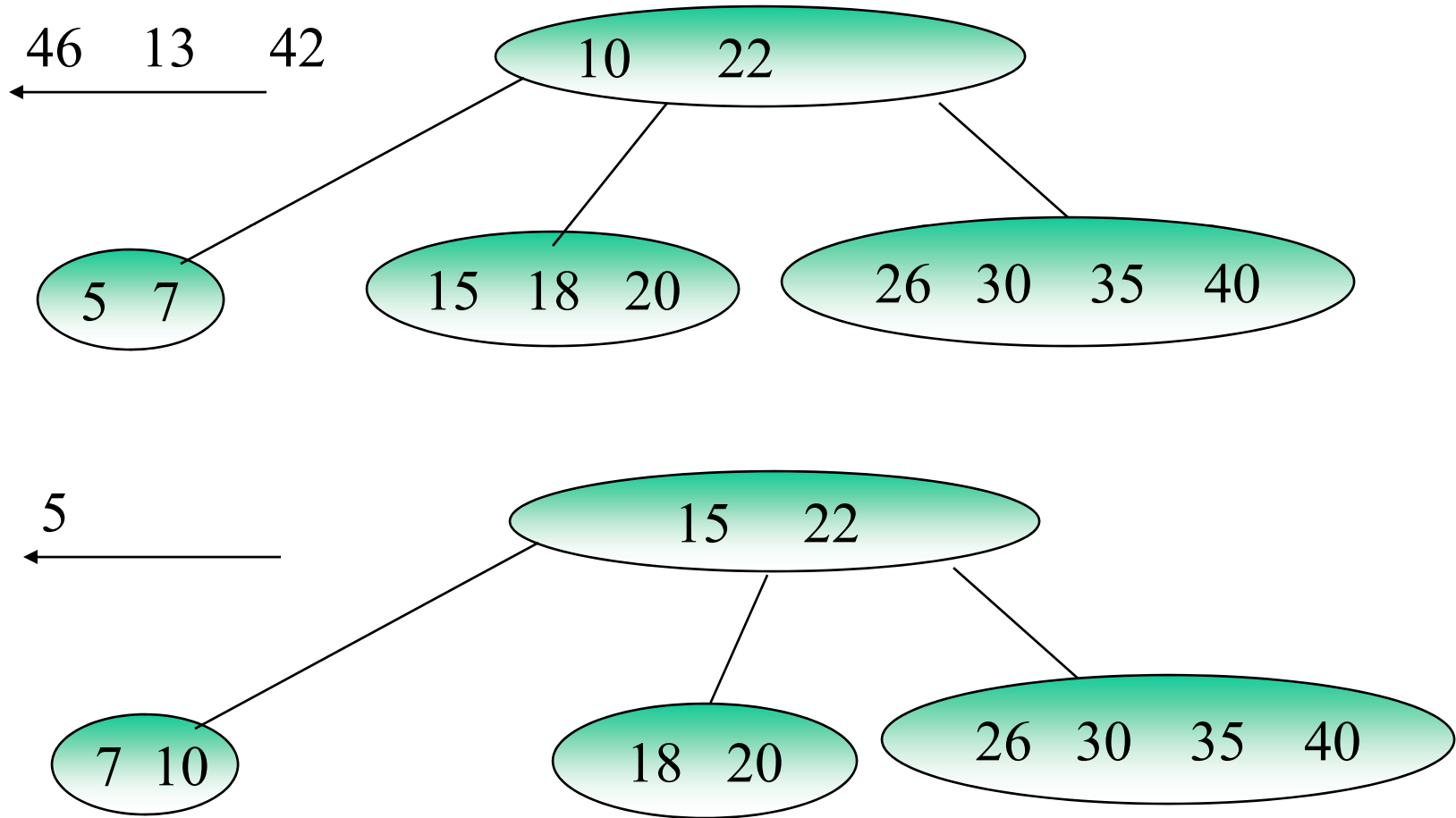


Deletion examples ...



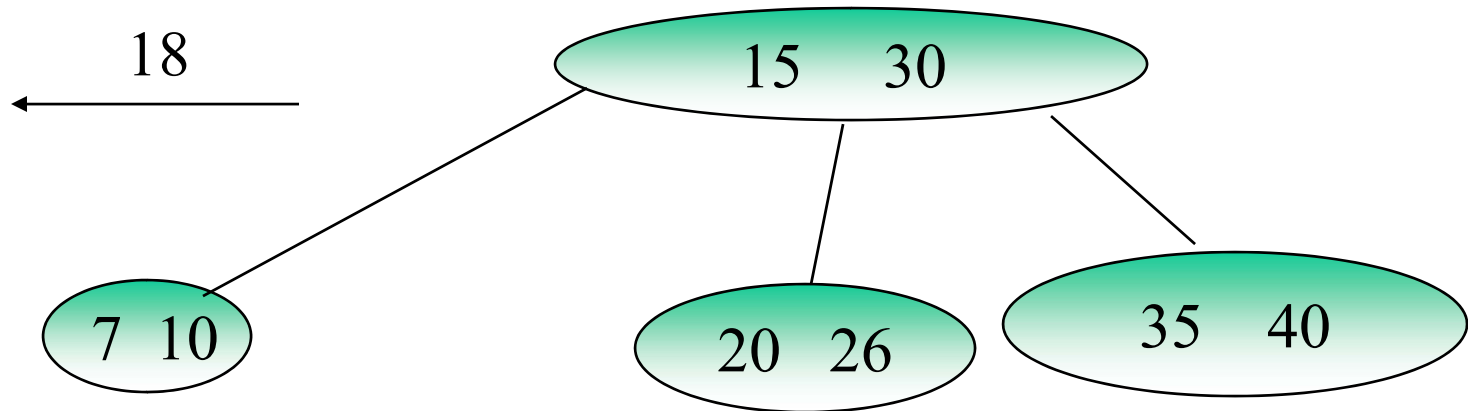
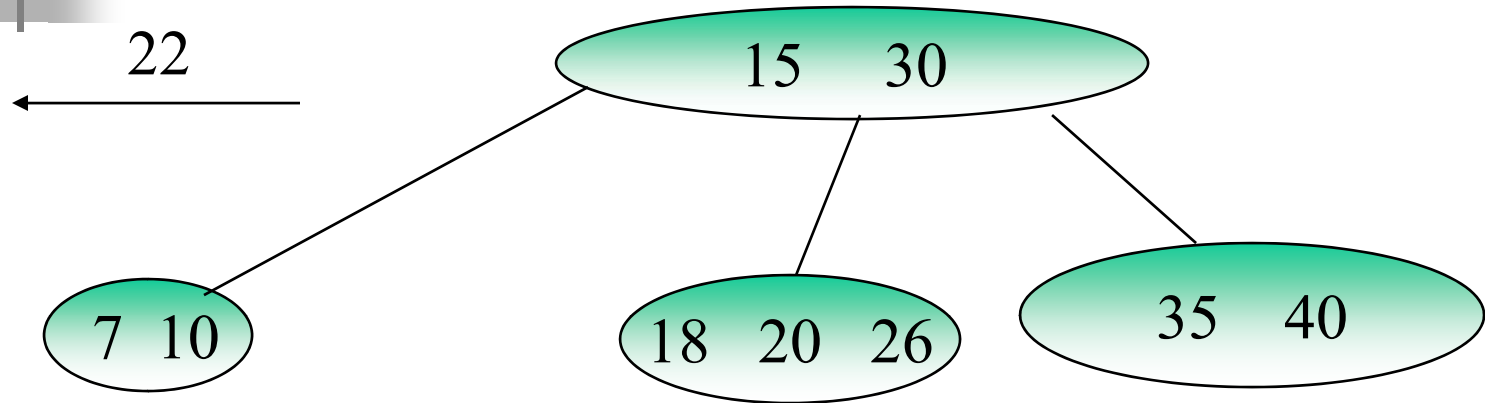


Deletion examples ...





Deletion examples ...



Delete 26 , 7 , 35 , 15