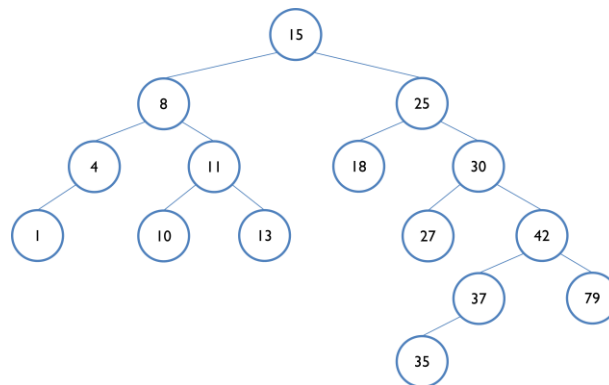




## Exercise Sheet 4: Trees & Advanced Indexes

### Exercise 1: Binary Search Trees

- a. Given is the following binary search tree. Delete the following nodes in the given order and show the tree after each deletion! 10, 4, 30, 15



- b. Tree Traversal: Access all nodes of the tree in Pre-Order, In-Order and Post-Order.

### Exercise 2: AVL Trees

- a. Build an AVL Tree by inserting the following keys step by step: I, D, J, F, C, A, B.  
b. Considering an AVL Tree with 100 keys. What is its maximal height?  
c. Show an AVL Tree which height is smaller after deleting and inserting the **same** key.  
d. Draw an AVL Tree with a minimum number of nodes whose external nodes are on three different levels.

### Exercise 3: B-Trees

- a. Build a B-Tree by inserting the keys 1 – 20 ( $k = 2^2$ ) in ascending order. What do you recognize?  
b. In which order must the keys be inserted in an empty B-Tree to have maximum split operations. Please explain your answer.

<sup>1</sup> Deletion if node has two children: Replace with In-Order successor

<sup>2</sup> k: minimum number of keys allowed for one node (exception: root node). The maximum number is  $2*k$ .