# Announcements

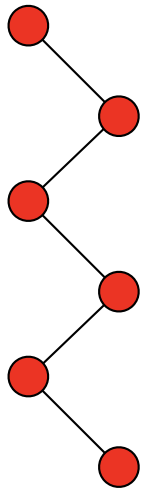
MP5 available, due 3/31, 11:59p. EC due 3/17, 11:59p.

http://www.qmatica.com/DataStructures/Trees/AVL/AVLTree.html

Binary Search Tree - miscellaneous characteristics and analysis

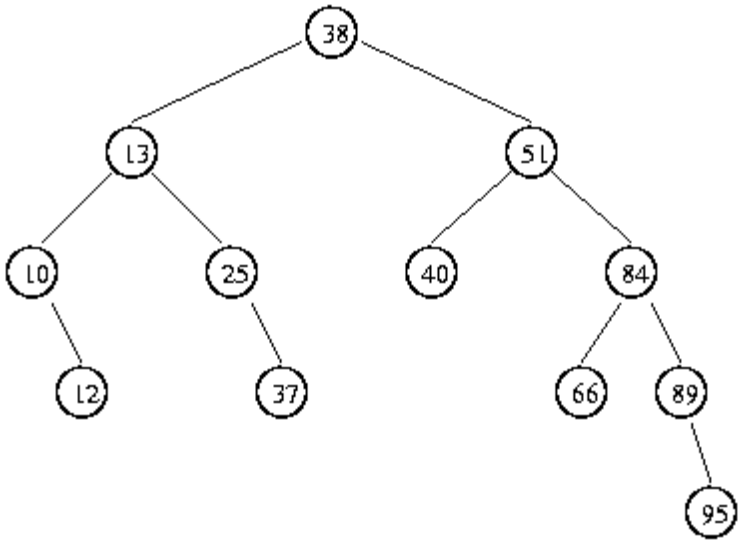
```
BST<int> myT;
myT.insert(2);
myT.insert(7);
myT.insert(15);
myT.insert(22);
myT.insert(28);
…
```

Give a sequence of inserts that result in a tree that looks like:



How many “bad” n-item trees are there?

# Binary Tree -




The *algorithms* on BST depend on the height (h) of the tree.

The *analysis* should be in terms of the amt of data (n) the tree contains.

So we need relationships between h and n.

$$h \geq f(n)$$

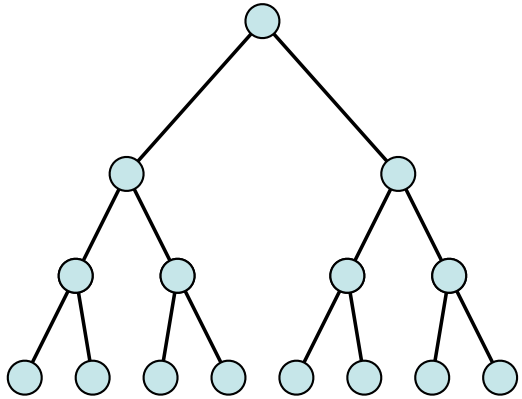
$$h \leq g(n)$$

Reminder:

height(T) is:

- _____ if T is empty
- 1 + max{height($T_L$), height($T_R$)}, otherwise

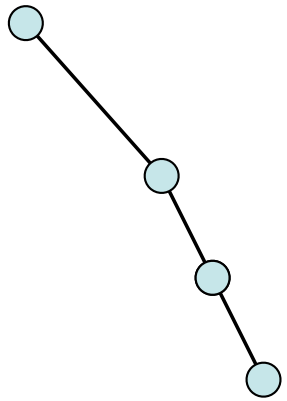
# Binary Tree  (theory moment #1)



what is maximum number of nodes in a tree of height h?

what is the least possible height (h) for a tree of n nodes?

# Binary Tree (theory moment #2)



what is minimum number of nodes (n) in a tree of height h?

what is the greatest possible height (h) for a tree of n nodes?

thus:  lower bd on ht _____, upper bd on ht _____,  good news or bad?

# Binary Search Tree -

The height of a BST depends on the order in which the data is inserted into it.

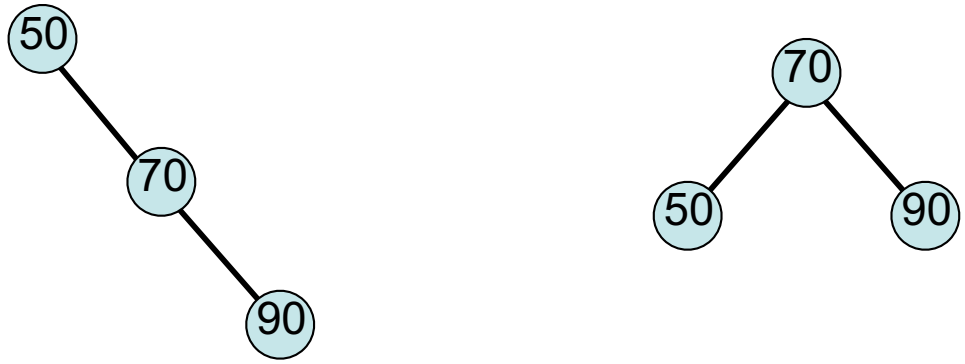
ex. 1 3 2 4 5 7 6  vs.  4 2 3 6 7 1 5

How many different ways are there to insert n keys into a tree?

Avg height, over all arrangements of n keys is _____.

| operation | avg case | worst case | sorted array | sorted list |
|---|---|---|---|---|
| find | | | | |
| insert | | | | |
| delete | | | | |
| traverse | | | | |

something new… which tree makes you happiest?



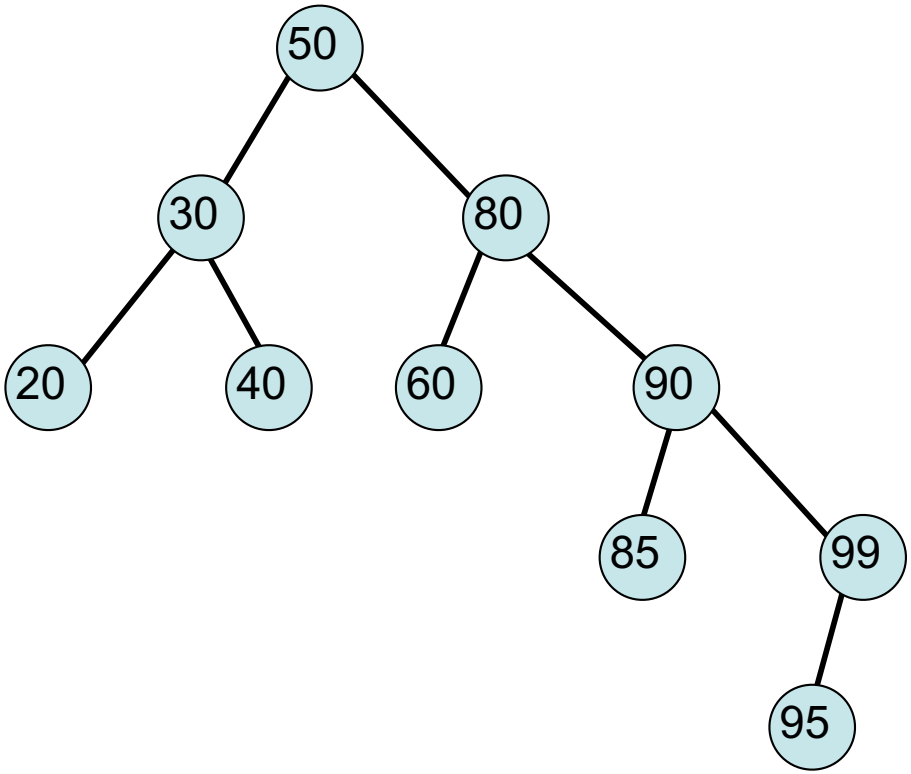

The “height balance” of a tree T is:

$$b = height(T_L) - height(T_R)$$

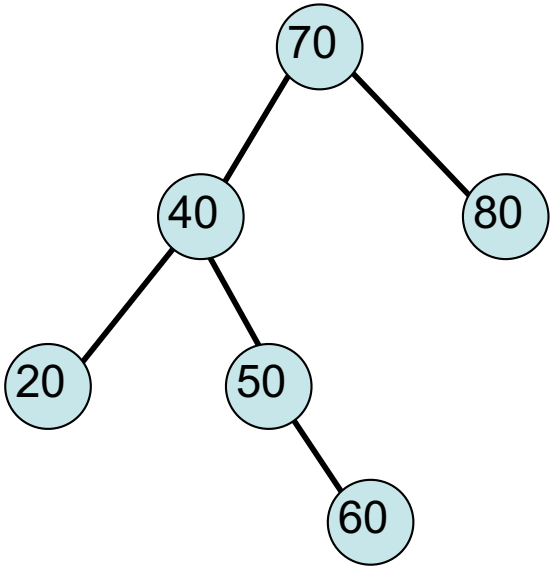
A tree T is “height balanced” if:

- 
- 

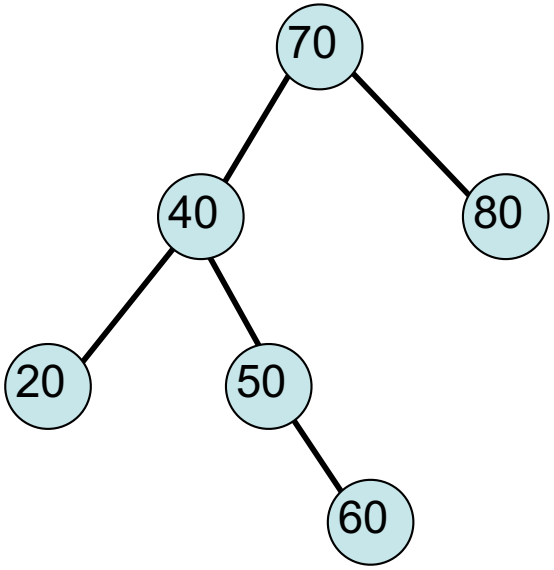
# operations on BST - rotations



# balanced trees - rotations



# balanced trees - rotations



balanced trees - rotations summary:

- there are 4 kinds: left, right, left-right, right-left (symmetric!)
- local operations (subtrees not affected)
- constant time operations
- BST characteristic maintained

GOAL: use rotations to maintain balance of BSTs.

height balanced trees - we have a special name:

Three issues to consider as we move toward implementation:

Rotating

Maintaining height

Detecting imbalance