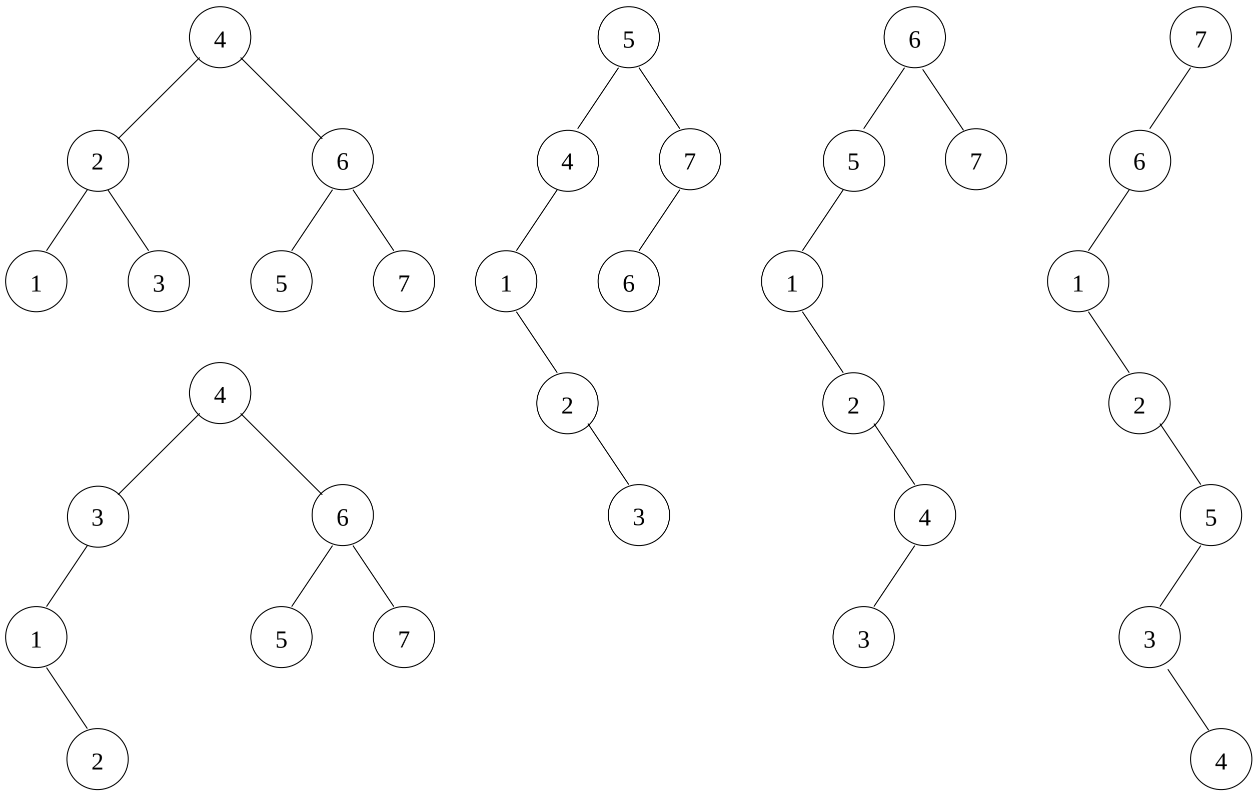
Analysis of Algorithms: Solutions 5

```
                X
                X   X       X
                X   X       X
                X   X       X
                X   X       X   X
            X   X   X       X   X
            X   X   X   X   X   X
X           X   X   X   X   X   X   X
--------------------------------------
1   2   3   4   5   6   7   8   9   10
              grades
```

Problem 1
Draw five binary search trees, with heights two, three, four, five, and six. Each tree should have seven nodes, and the keys of these nodes should be 1, 2, 3, 4, 5, 6, and 7.



Problem 2

Give a recursive version of the TREE-INSERT procedure.

RECURSIVE-INSERT(T, z)
if $root[T] = \text{NIL}$
   then $parent[z] \leftarrow \text{NIL}$
          $root[T] \leftarrow z$
   else ADD-NODE$(root[T], z)$

ADD-NODE(x, z)
if $key[z] < key[x]$
   then if $left\text{-}child[x] \neq \text{NIL}$
            then ADD-NODE$(left\text{-}child[x], z)$
            else $parent[z] \leftarrow x$
                    $left\text{-}child[x] \leftarrow z$
   else if $right\text{-}child[x] \neq \text{NIL}$
            then ADD-NODE$(right\text{-}child[x], z)$
            else $parent[z] \leftarrow x$
                    $right\text{-}child[x] \leftarrow z$

Problem 3

Give a nonrecursive version of INORDER-TREE-WALK.

ITERATIVE-TREE-WALK(T)
$x \leftarrow$ TREE-MINIMUM$(root[T])$
while $x \neq \text{NIL}$
      do print $key[x]$
          $x \leftarrow$ TREE-SUCCESSOR(x)

Problem 4

Write a procedure INORDER-RANGE-WALK$(x,\ min,\ max)$ that recursively prints all nodes between min and max in the subtree rooted at x. It should be *more efficient* than INORDER-TREE-WALK; thus, it should not traverse the whole subtree.

INORDER-RANGE-WALK$(x,\ min,\ max)$
if $x \neq \text{NIL}$
   then if $min \leq key[x]$
            then INORDER-RANGE-WALK$(left\text{-}child[x],\ min,\ max)$
         if $min \leq key[x] \leq max$
            then print $key[x]$
         if $key[x] \leq max$
            then INORDER-RANGE-WALK$(right\text{-}child[x],\ min,\ max)$