

R-3.11 Consider the following sequence of keys:

(5, 16, 22, 45, 2, 10, 18, 30, 50, 12, 1)

Consider the insertion of items with this set of keys, in the order given, into:

- a. an initially empty (2,4) tree  $T'$ .
- b. an initially empty red-black tree  $T''$ .

Draw  $T'$  and  $T''$  after each insertion.

R-3.14 For each of the following statements about red-black trees, determine whether it is true or false. If you think it is true, provide a justification. If you think it is false, give a counterexample.

- a. a subtree of a red-black tree is itself a red-black tree.
- b. the sibling of an external node is either external or it is red.
- c. given a red-black tree  $T$ , there is a unique (2,4) tree  $T'$  associated with  $T$ .
- d. given a (2,4) tree  $T$ , there is a unique red-black tree  $T'$  associated with  $T$ .

C-3.10 Let  $D$  be an ordered dictionary with  $n$  items implemented by means of an AVL tree (or a Red-Black tree). Show how to implement the following operation on  $D$  in time  $O(\log n + s)$ , where  $s$  is the size of the iterator returned:

FindAllInRange( $k_1, k_2$ ):

Return an iterator of all the elements in  $D$  with key  $k$  such that  $k_1 \leq k \leq k_2$ .