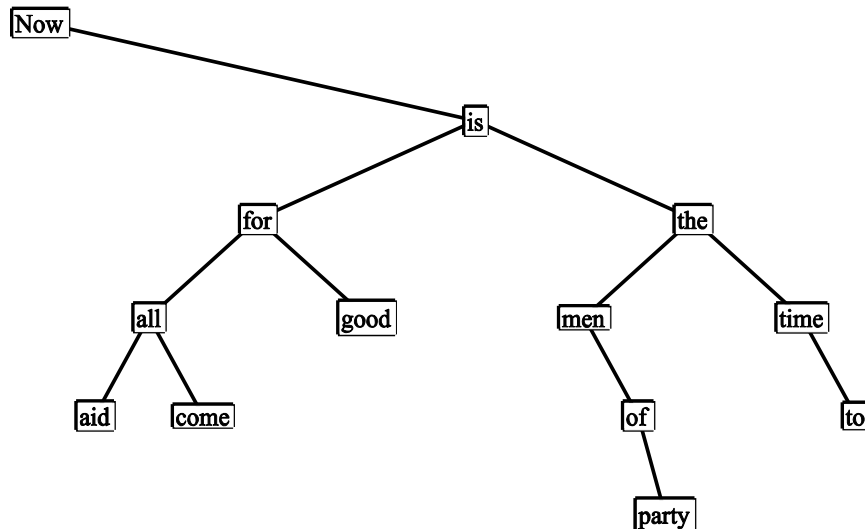## 9.1.1

Draw the binary search tree that results from inserting the words of the sentence "Now is the time for all good men to come to the aid of the party." What is its height? Compare this with 4, the smallest integer greater than $\log_2 13$, where 13 is the number of distinct words in this sentence.

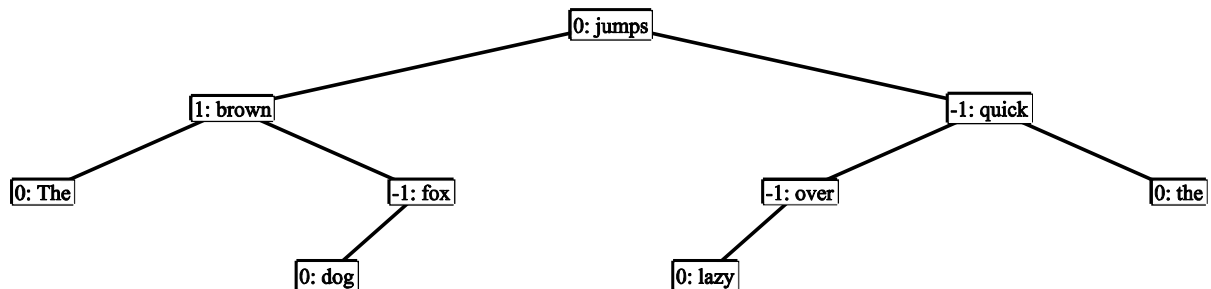The height of this tree is 6 which is 2 greater than 4.

9.1.3

Describe the algorithm for rotation left.

1. Remember the value of `root.right` (`temp = root.right`).
2. Set `root.right` to the value of `temp.left`.
3. Set `temp.left` to root.
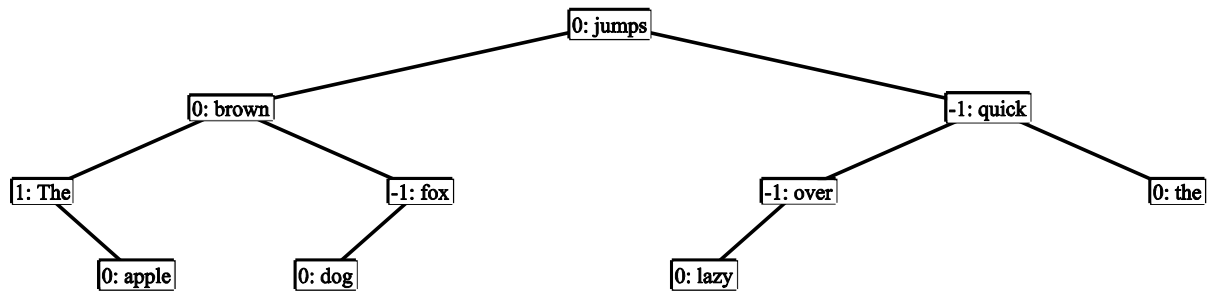**4.** Set root to `temp`.

9.2.1

Show how the final AVL tree for the "The quick brown fox" changes as you insert "apple", "cat", and "hat" in that order.
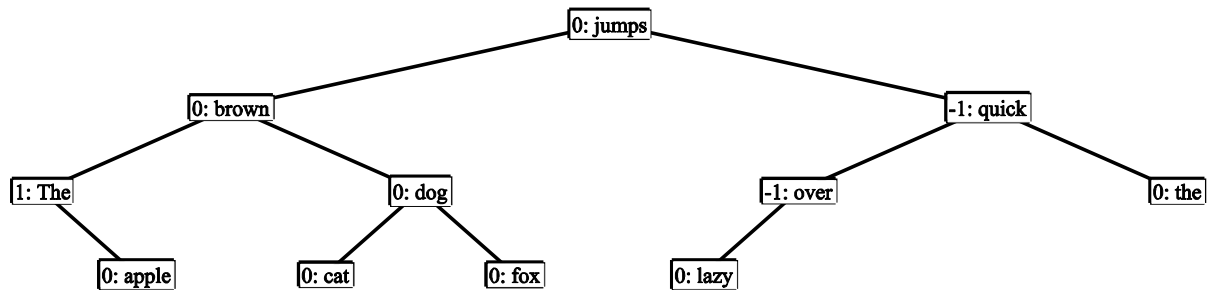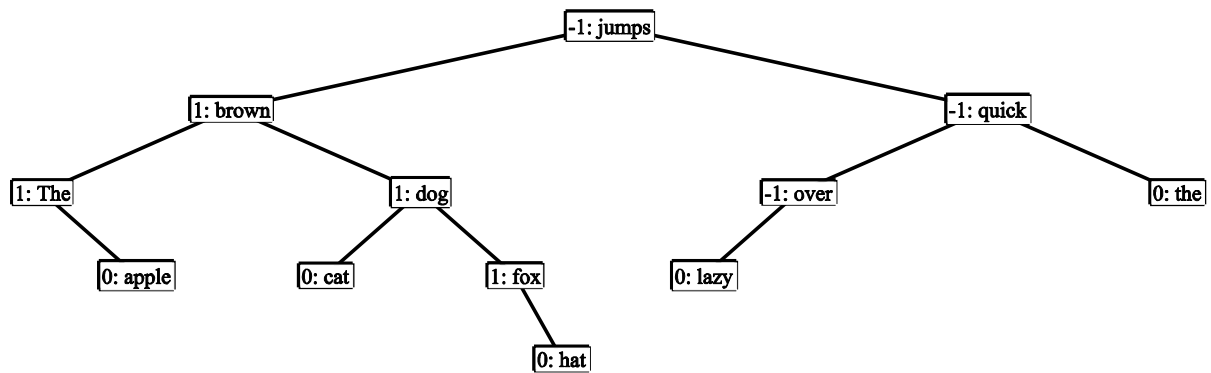
Original AVL tree:

After inserting "apple":

0: jumps
0: brown
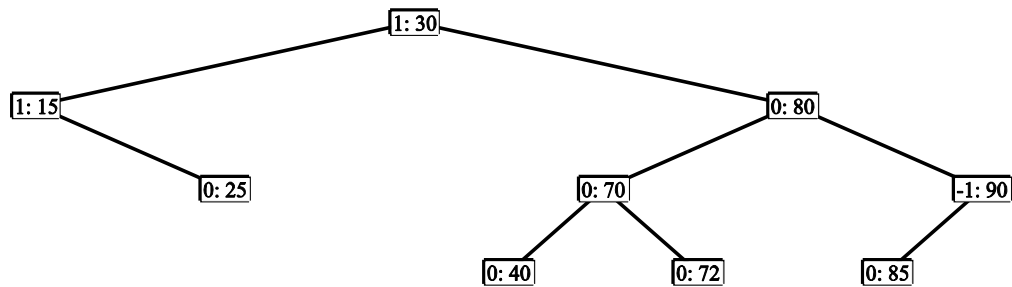-1: quick
1: The
-1: fox
-1: over
0: the
0: apple
0: dog
0: lazy

After inserting "cat":

0: jumps
0: brown
-1: quick
1: The
0: dog
-1: over
0: the
0: apple
0: cat
0: fox
0: lazy

After inserting "hat"

-1: jumps
1: brown
-1: quick
1: The
1: dog
-1: over
0: the
0: apple
0: cat
1: fox
0: lazy
0: hat

9.2.3

Build an AVL tree that inserts the integers 30, 40, 15, 25, 90, 80, 70, 85, 15, 72 in the given order.

1: 30
1: 15
0: 80
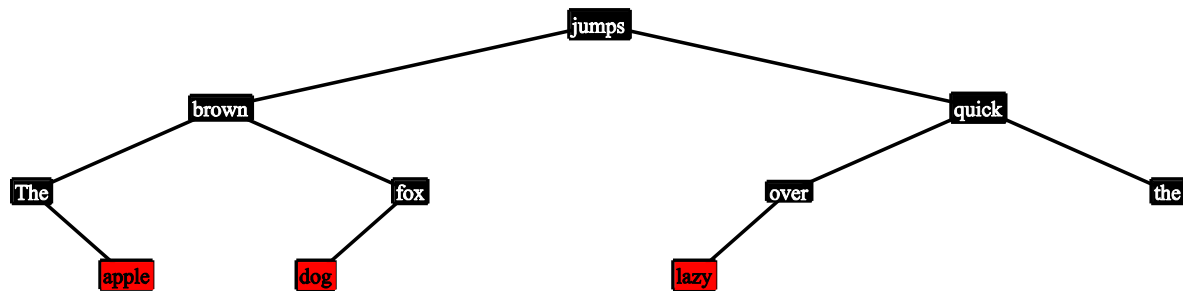0: 25
0: 70
-1: 90
0: 40
0: 72
0: 85

9.3.1

Show how the final Red-Black tree for the "The quick brown fox" changes as you insert "apple", "cat", and "hat" in that order.
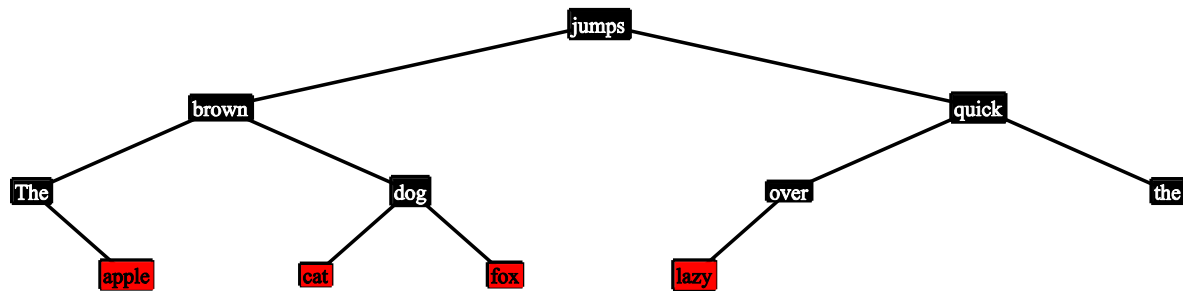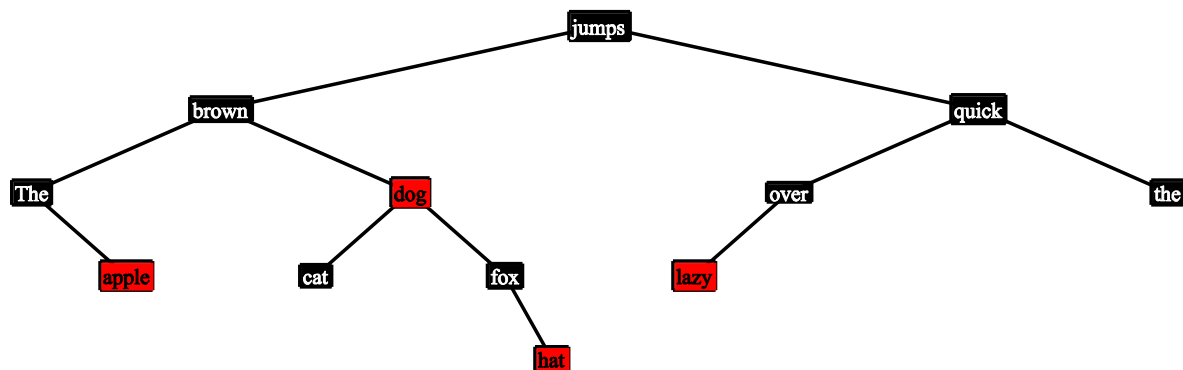
Original Red-Black Tree of "The quick brown fox"
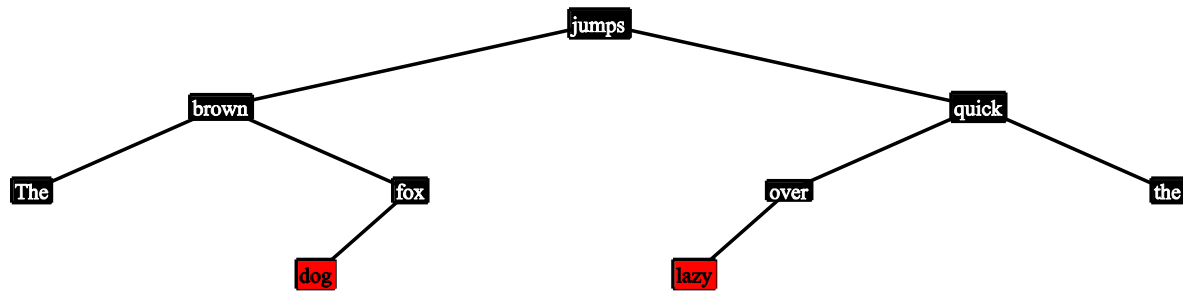
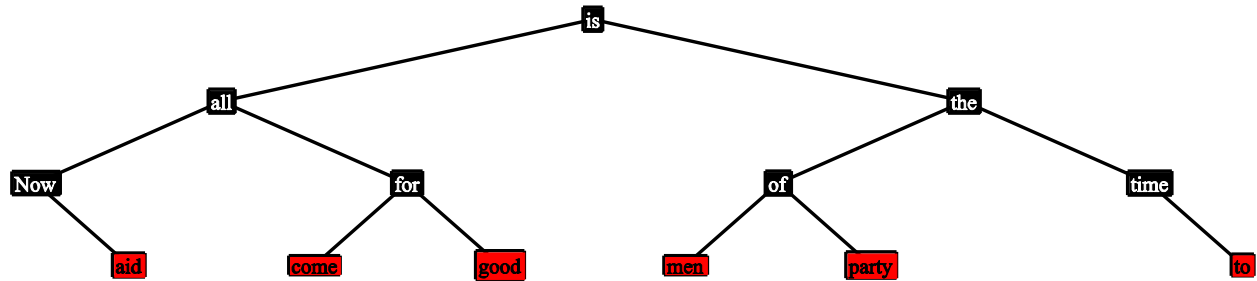After adding "apple"

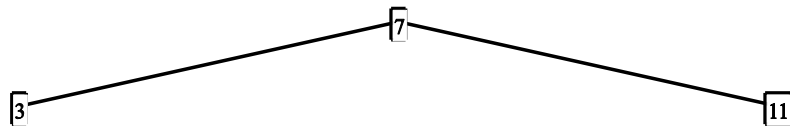After inserting "cat"

After inserting "hat"

9.3.3

Build the Red-Black tree from the sentence "Now is the time for all good men to come to the aid of the party". Is it the same as the AVL tree?
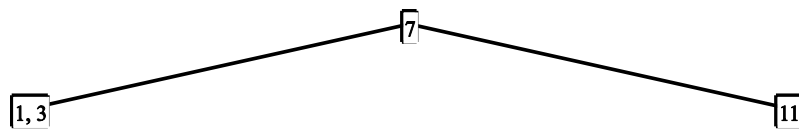

The Red-Black and AVL trees are the same. They are also equivalent to the minimal height tree from question 9.1.2.
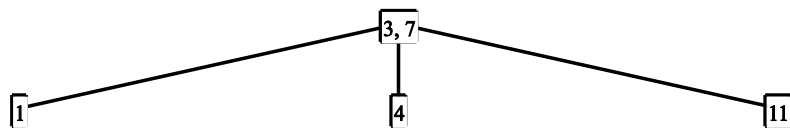
9.4.1

Show the following 2-3 tree after inserting each of the following values one at a time: 1, 4, 9.
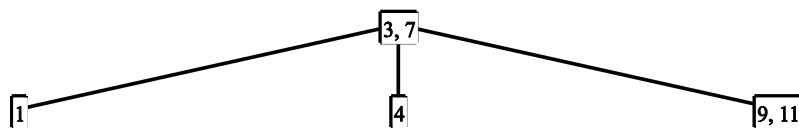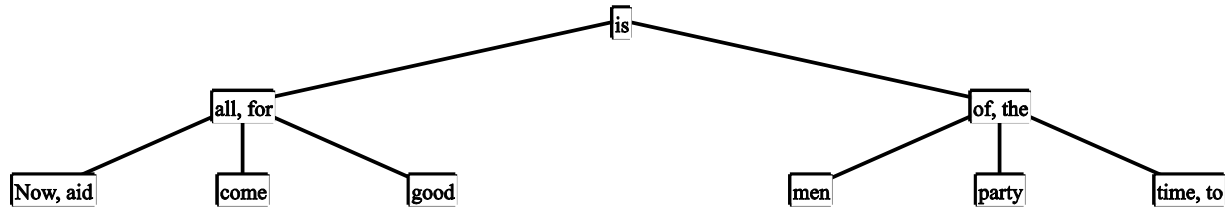

After inserting 1

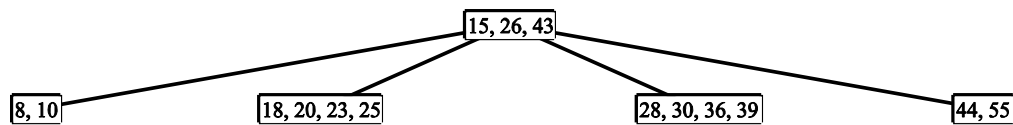After inserting 4

After inserting 9

9.4.3

Show the 2-3 tree that would be built for the sentence "Now is the time for all good men to come to the aid of their party".
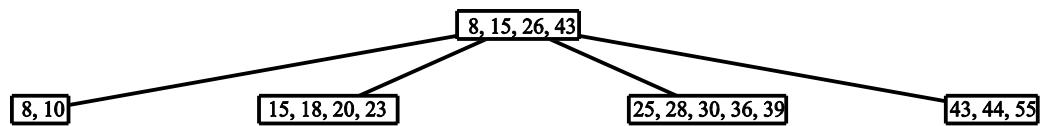
```
                                    is
                   ┌────────────────┴────────────────┐
                all, for                           of, the
            ┌─────┼─────┐                      ┌──────┼──────┐
        Now, aid  come  good                  men   party  time, to
```

9.5.1

Draw a B-tree with order 5 that stores the sequence of integers: 20, 30, 8, 10, 15, 18, 44, 26, 28, 23, 25, 43, 55, 36, 44, 39.
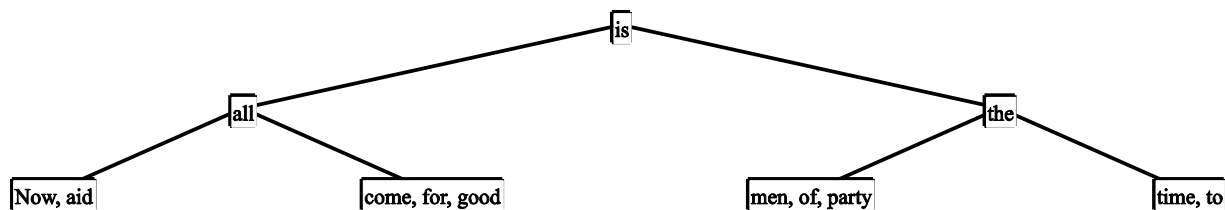
```
                            15, 26, 43
            ┌───────────┬──────┴──────┬───────────┐
         8, 10    18, 20, 23, 25   28, 30, 36, 39   44, 55
```

9.5.3

Draw the B+ tree that would be formed by inserting the integers shown in Exercise 1.

```
                           8, 15, 26, 43
            ┌───────────┬──────┴──────┬───────────┐
         8, 10    15, 18, 20, 23   25, 28, 30, 36, 39   43, 44, 55
```
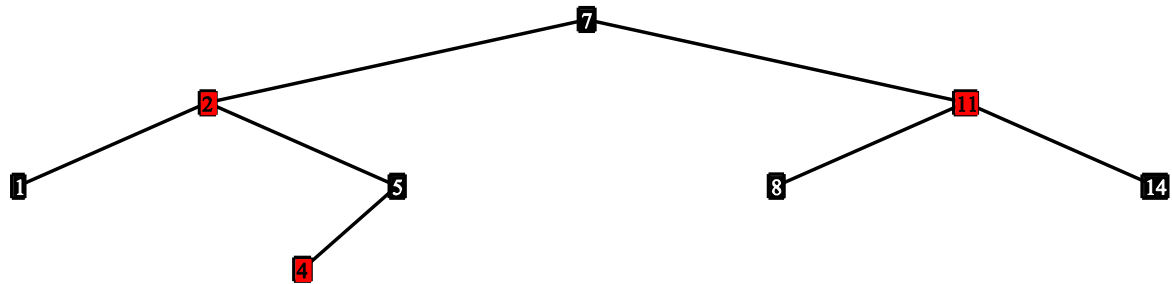
9.5.5

Build a 2-3-4 tree to store the words in the sentence "Now is the time for all good men to come to the aid of their party".

```
                                    is
                   ┌────────────────┴────────────────┐
                  all                                the
            ┌──────┴──────┐                    ┌──────┴──────┐
        Now, aid    come, for, good      men, of, party    time, to
```
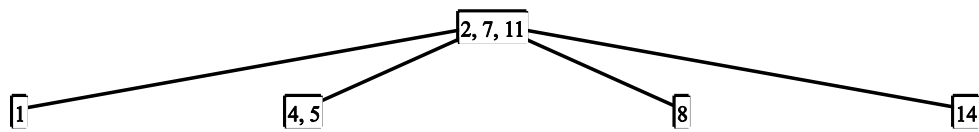
9.5.7

Draw the 2-3-4 tree equivalent to the following Red-Black tree.
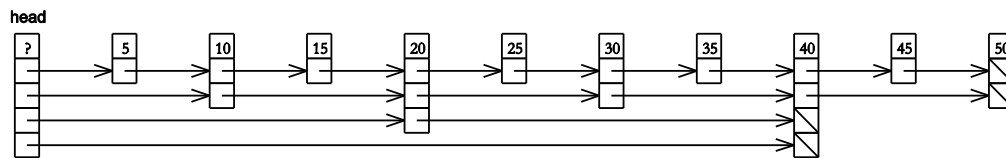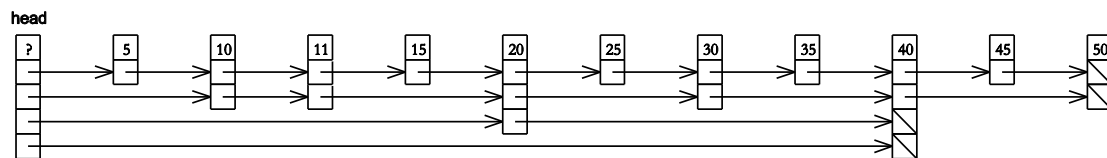

Equivalent 2-3-4 tree:

9.6.1

Show the skip-list after inserting the values 11, 12, 22, and 33 into the skip-list shown in Figure 9.65. Assume that the random number generator returned 2, 1, 3, and 1 for the new node levels.
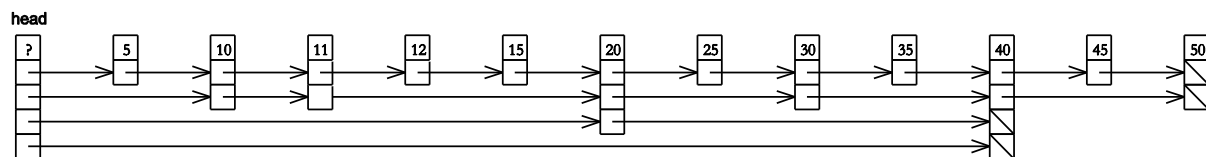
Original Figure 9.65
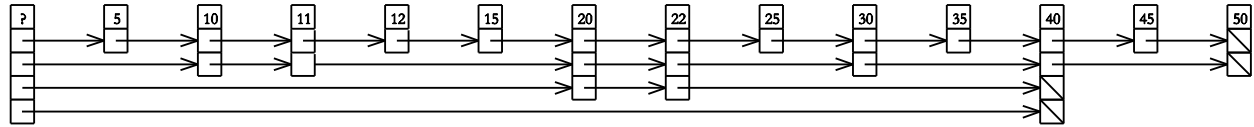

After inserting 11 at level 2

After inserting 12 at level 1

After inserting 22 at level 3

After inserting 33 at level 1