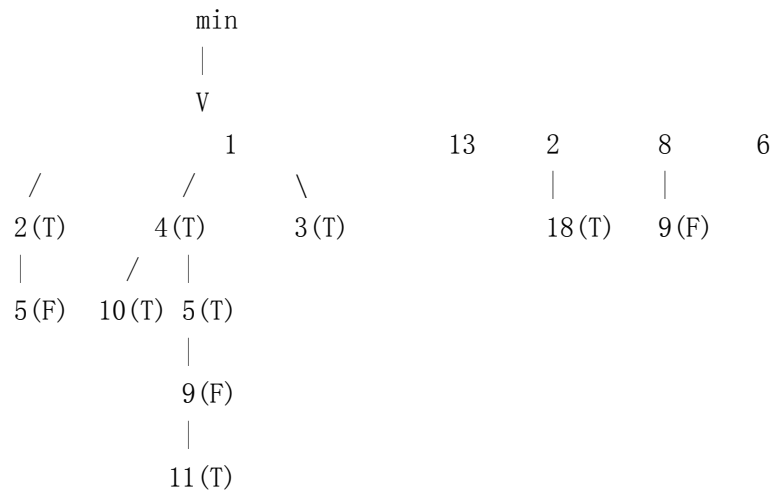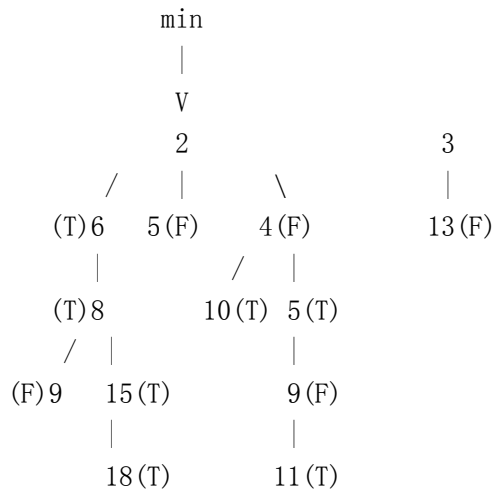Exam02_solution
    Spring, 2004

question 1.
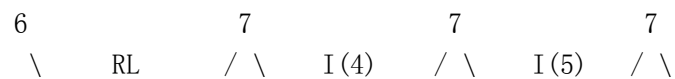

DecreaseKey operation by changing 15 by 2

```
                          min
                           |
                           V
                           1              13    2      8      6
             /          /     \                 |      |
          2(T)       4(T)    3(T)             18(T)   9(F)
           |        /   |
          5(F)   10(T) 5(T)
                        |
                       9(F)
                        |
                      11(T)
```
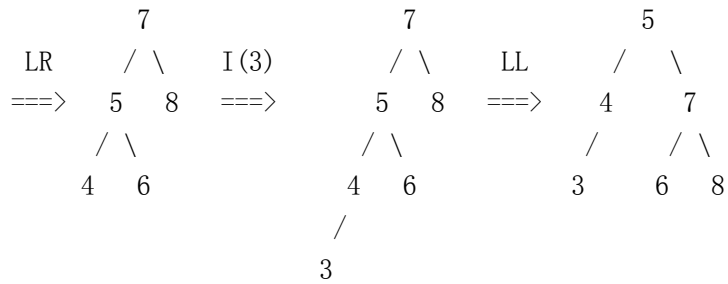

DeleteMin operation.

```
            min
             |
             V
             2                      3
          /   |    \                |
      (T)6   5(F)    4(F)          13(F)
         |        /    |
      (T)8     10(T)  5(T)
       /  |            |
   (F)9  15(T)        9(F)
          |            |
        18(T)        11(T)
```


(2) (a)
```
          6              7              7              7
           \     RL     / \     I(4)   / \    I(5)    / \
```
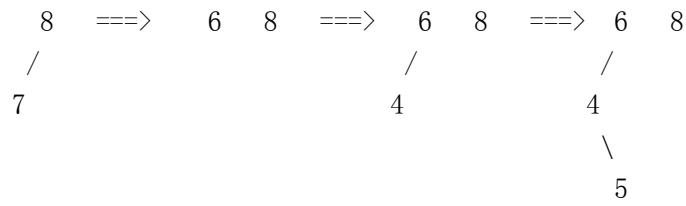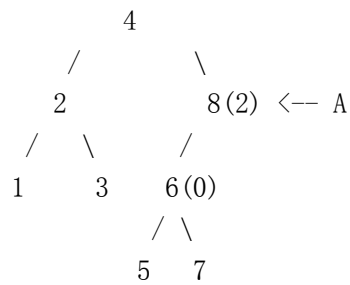
```
    8    ===>    6  8   ===>   6  8   ===>  6  8
   /            /             /            /
  7                          4            4
                                           \
                                            5


          7                     7                     5
  LR     / \      I(3)         / \        LL         / \
 ===>   5   8    ===>         5   8      ===>       4   7
       / \                   / \                   /   / \
      4   6                 4   6                 3   6   8
                          /
                         3

(b) delete 9

                4
              /     \
            2         8(2) <-- A
           / \       /
          1   3    6(0)
                  / \
                 5   7
    A is the nearest ancestor of the deleted node.  (R0)

                4
              /     \
            2         6
           / \       / \
          1   3     5   8
                       /
                      7


3)

   (a) tree with smaller root becomes leftmost subtree.
         Insert 5           Insert 8           Insert 4
      2        ==>    5          ==>    8          ==>        8
                      |                 |                   /   \
                      2                 5                  4     5
                                        |                        |
                                        2                        2
```
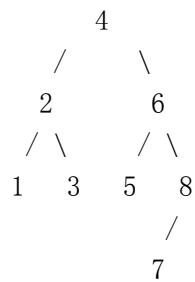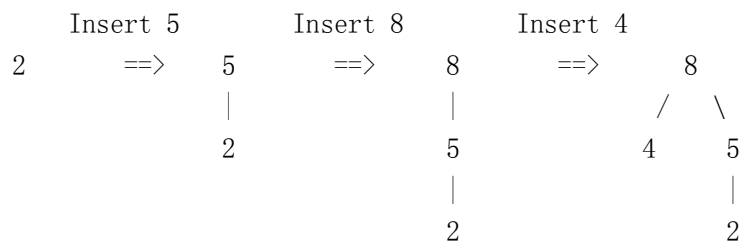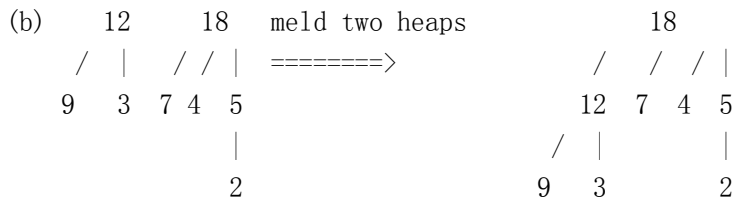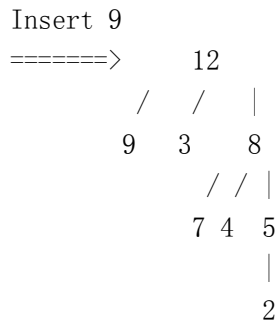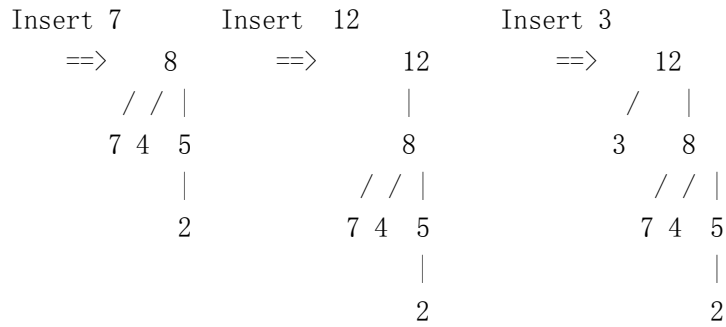
```
          Insert 7         Insert  12          Insert 3
            ==>    8          ==>       12          ==>    12
                 / / |                   |               /   |
                7 4  5                   8              3    8
                     |                  / / |               / / |
                     2                 7 4  5              7 4  5
                                           |                   |
                                           2                   2


          Insert 9
          ======>      12
                     /   /   |
                    9   3    8
                           / / |
                          7 4  5
                              |
                              2



(b)    12       18   meld two heaps              18
      /  |    / / |  =======>               /   /  / |
     9   3   7 4  5                        12  7  4  5
                  |                       /  |        |
                  2                      9   3        2



(c) two-pass meld after remove min
 pass 1: start subtrees left to right.
        13    12    9     7
        |     |     |
        10    11    5


        the number of subtrees was odd,
     meld remaining original subtree with newly generated subtree.



     13    12       9
                |     |    /  |
                10    11   7   5


 Pass 2: start with rightmost subtrees of pass 1
                12                    13
```
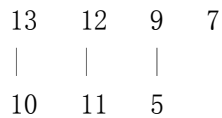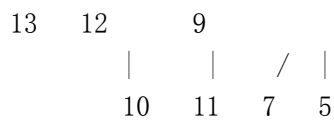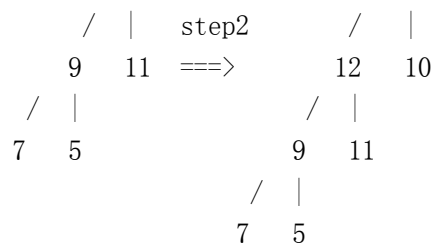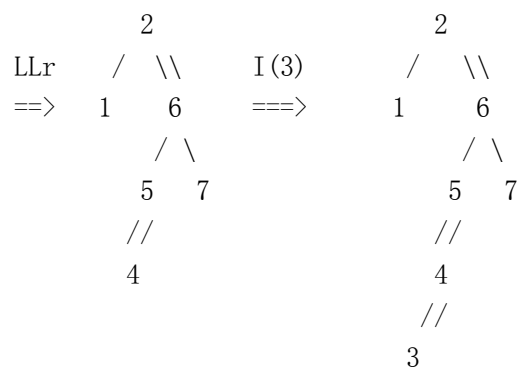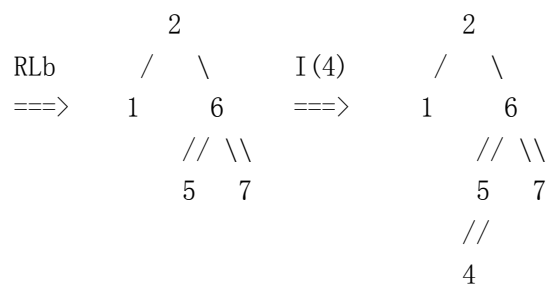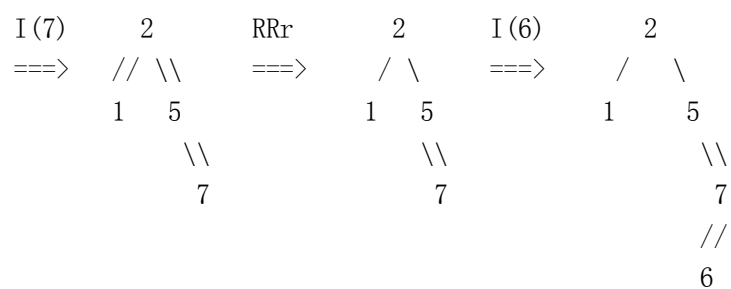
```
          /  |    step2         /   |
        9    11  ===>        12    10
      /  |                    /  |
     7   5                   9   11
                              /  |
                             7   5
```

(4)
 (a)

```
 I(7)      2        RRr        2        I(6)         2
 ===>    // \\      ===>     /  \       ===>       /    \
        1    5             1    5                1      5
              \\                 \\                      \\
               7                  7                       7
                                                         //
                                                         6
```

```
            2                        2
 RLb      /   \         I(4)       /   \
 ===>   1      6        ===>     1      6
              // \\                    // \\
              5    7                   5    7
                                      //
                                      4
```

```
          2                       2
 LLr    /  \\         I(3)       /    \\
 ==>   1     6       ===>      1       6
            /  \                      /  \
           5    7                    5    7
          //                         //
          4                          4
                                    //
                                    3
```

```
           2
 LLb       /  \\
```

```
==>      1    6
              / \
            4    7
          // \\
          3    5
```

(b)

    delete 14

```
            10
          /       \\
        8           15
      // \\        /  \
      7   9      12    y
                // \\
              11    13
```

Rb2

```
            10
          /       \\
        8           13
      // \\        /  \
      7   9      12    15
                //
              11
```