

Instructor: Dr. Sartaj Sahni
Spring, 2005

Advanced Data Structures
(COP 5536)
Exam 2

CLOSED BOOK
60 Minutes

Name: _____

NOTE:

1. **For all problems, use only the algorithms discussed in class/text.**
2. All answers will be graded on correctness, efficiency, clarity, elegance and other normal criteria that determine quality.
3. The points assigned to each question are provided in parentheses.

1. (10) For *min Fibonacci heaps*:

- (a) (5) Perform the following sequence of operations on an initially empty *min Fibonacci heap* in this order:

Insert(18), Insert(10), Insert(16), Insert(6), Insert(4), Insert(15), RemoveMin

Draw min Fibonacci heaps before and after performing the *remove min* operation.

- (b) (5) For the *min Fibonacci heap* shown in Figure 1, perform a *DecreaseKey* operation by changing 33 to 4. *T* represents a *ChildCut* of *TRUE* and *F* represents *FALSE*.

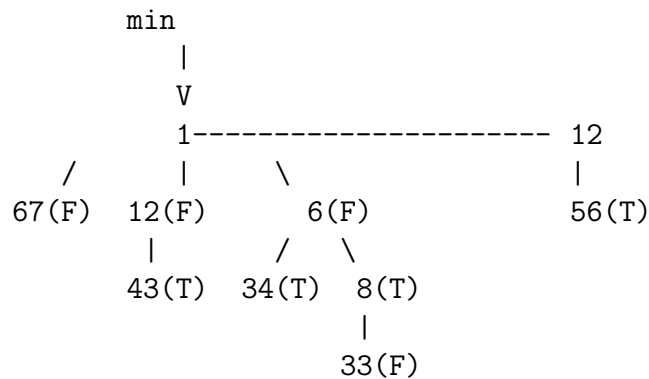


Figure 1. Min Fibonacci heap

Draw the resulting *min Fibonacci heap* and clearly label *ChildCut* values.

2. (8) For the *two-pass max pairing heap* shown in Figure 2,

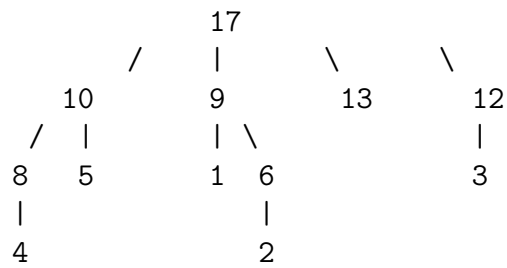


Figure 2. Max pairing heap

- (a) (4) Perform a *RemoveMax* operation. Show each step.
- (b) (4) Perform *remove(9)* from the original max pairing heap shown in Figure 2. Show each step.

3. (6) Start with an empty AVL tree, perform *insert* operations using the following keys in the order: 12, 10, 8, 14, 16, and 11. Show each step and specify rotation type if applied.

4. (12) For *2-3 trees*,

- (a) (6) Perform *Insert(30)* on the 2-3 tree shown in Figure 3. Draw the resulting *2-3 tree* and explain how you get your result.

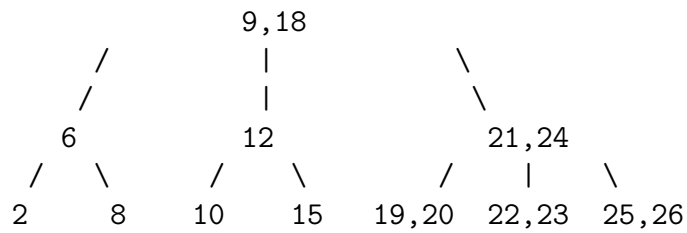


Figure 3. 2-3 tree

- (b) (6) Construct a *2-3 tree* with height 3 (i.e., the tree has 3 levels) that consists of only 2-nodes. Delete the key value of the *root* node. Show each step. (*Root node is at height 1.*)

5. (14) For *red-black* trees, use the *bottom-up* algorithm for this problem. Double lines indicate a red edge and single line a black edge.

(a) (8) Perform the following sequence of operations on the red-black tree shown in Figure 4 in this order:

Insert(7), Insert(4), Delete(10)

Show each step and specify rotation type/color flip/rebalancing strategy if applied.

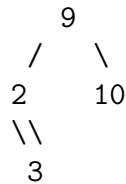


Figure 4. Red-black tree

(b) (6) Consider the red-black tree shown in Figure 5. Perform *Split(18)* operation, showing each step.

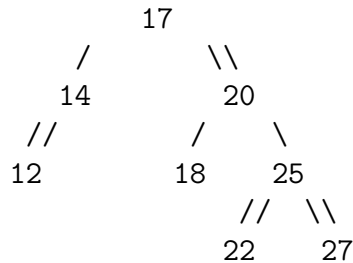


Figure 5. Red-black tree