Data Structures in Java - Homework 7

Problem 1

5.1 Given input {4371, 1323, 6173, 4199, 4344, 9679, 1989} and a hash function $h(x) = x \bmod 10$, show the resulting:
a. Separate chaining hash table.
b. Hash table using linear probing.
c. Hash table using quadratic probing.

Answer:

(a) Index		(b) Index		(c) Index	
0		0	9679	0	9679
1	4371	1	4371	1	4371
2		2	1989	2	
3	1323 → 6173	3	1323	3	1323
4	4344	4	6173	4	6173
5		5	4344	5	4344
6		6		6	
7		7		7	
8		8		8	1989
9	4199 → 9679 → 1989	9	4199	9	4199

Problem 2

5.2 Show the result of rehashing the hash tables in Exercise 5.1.
Use Table size of 23

Answer:

Same for all (a), (b) and (c):

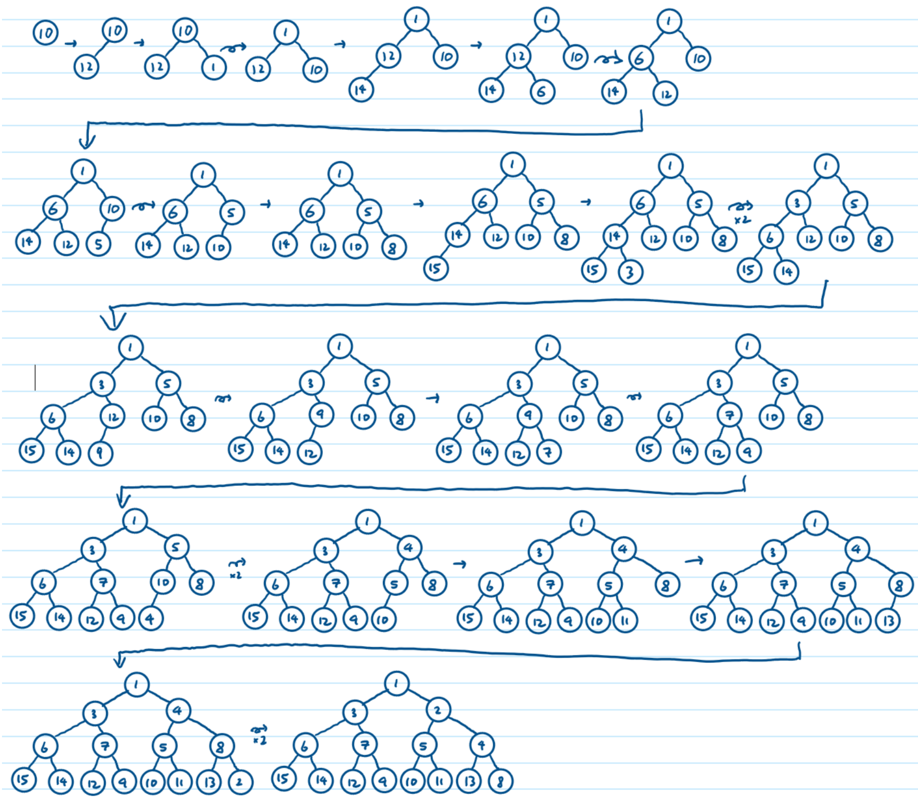
Index					
0		8		16	
1	4371	9	6173	17	
2		10		18	
3		11	1989	19	9679
4		12	1323	20	4344
5		13	4199	21	
6		14		22	
7		15			

Problem 3

6.2 a. Show the result of inserting 10, 12, 1, 14, 6, 5, 8, 15, 3, 9, 7, 4, 11, 13, and 2, one at a time, into an initially empty binary heap.

b. Show the result of using the linear-time algorithm to build a binary heap using the same input.

a) Answer:



b) Answer:

X	1	3	2	6	7	5	4	15	14	12	9	10	11	13	8

Problem 4

6.16 Suppose that binary heaps are represented using explicit links. Give a simple algorithm to find the tree node that is at implicit position i.

Answer:

Breadth-first traversal method and incrementing counter.

```
public BinaryNode get(BinaryNode root, int i)
{
    if (root == null || i < 1) return null;

    ArrayList<BinaryNode> queue = new ArrayList<BinaryNode>();
    queue.add(root);

    int currPos = 0;

    while (!queue.isEmpty()) {
        currPos++;
        BinaryNode currNode = queue.remove(0);

        if (currPos == i) {
            return currNode;
        }

        if (currNode.left != null) {
            queue.add(currNode.left);
        }
        if (currNode.right != null) {
            queue.add(currNode.right);
        }
    }

    return null;
}
```

Problem 5

6.18 A **min-max heap** is a data structure that supports both `deleteMin` and `deleteMax` in $O(\log N)$ per operation. The structure is identical to a binary heap, but the heap-order property is that for any node, X, at even depth, the element stored at X is smaller than the parent but larger than the grandparent (where this makes sense), and for any node X at odd depth, the element stored at X is larger than the parent but smaller than the grandparent. See Figure 6.57.

a. How do we find the minimum and maximum elements?

*b. Give an algorithm to insert a new node into the min-max heap.

a) Answer:

Minimum is the root. Maximum is the larger child of the root.

b) Answer:

- Insert at the next available left-most leaf position on the bottom level.
- If its depth is even:
  - While smaller than its grandparent, percolate up through only the even levels
  - while larger than grandparents, percolate up through only odd levels
- If its depth is odd,
  - While larger than its grandparent, percolate up through only the odd levels
  - While smaller than grandparents, percolate up through only even levels

Problem 6

7.1 Sort the sequence $3, 1, 4, 1, 5, 9, 2, 6, 5$ using insertion sort.

```
Original: [3, 1, 4, 1, 5, 9, 2, 6, 5]
Swap 1: [1, 3 | 4, 1, 5, 9, 2, 6, 5]
Swap 2: [1, 3, 4 | 1, 5, 9, 2, 6, 5]
Swap 3: [1, 1, 3, 4 | 5, 9, 2, 6, 5]
Swap 4: [1, 1, 3, 4, 5 | 9, 2, 6, 5]
Swap 5: [1, 1, 3, 4, 5, 9 | 2, 6, 5]
Swap 6: [1, 1, 2, 3, 4, 5, 9 | 6, 5]
Swap 7: [1, 1, 2, 3, 4, 5, 6, 9 | 5]
Swap 8: [1, 1, 2, 3, 4, 5, 5, 6, 9]
```