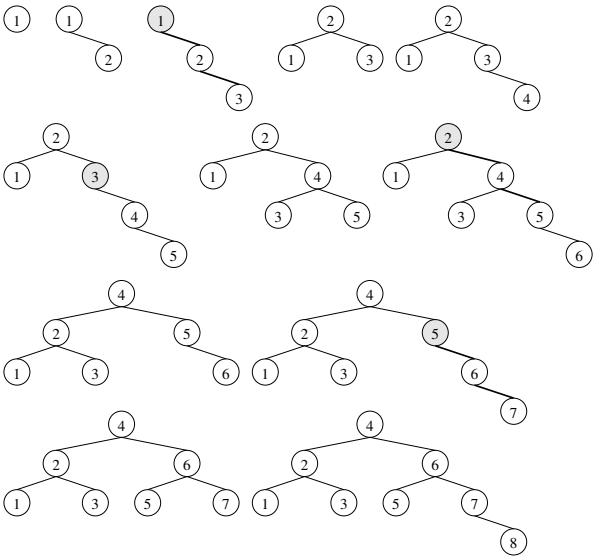
Data Structures 2018
Exercise 8, solutions (Week 44)

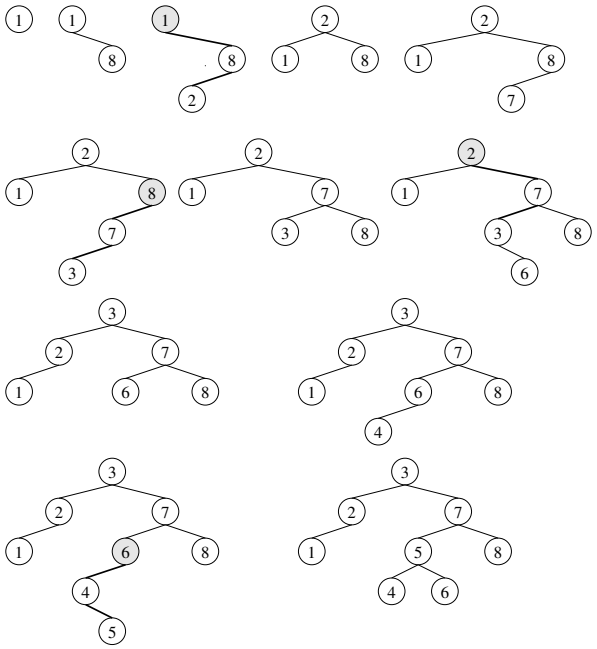
1.-3. In the file "`MinHeap.java`".

4. The darkened node is the first unbalanced node when we move upwards from the new node.

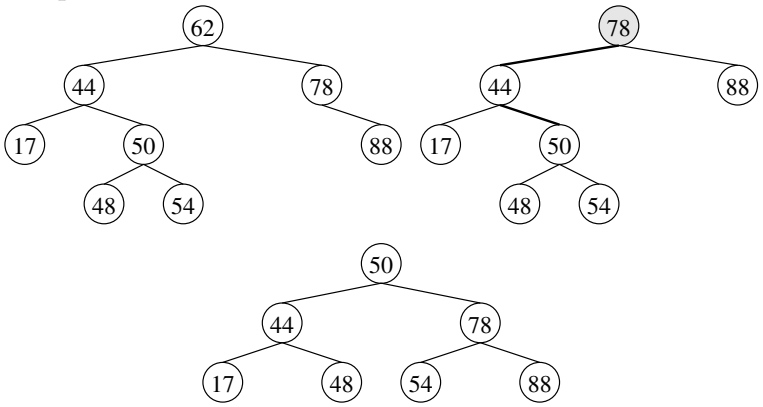
a)



b)



5. See picture below.



6. About the terminology: Closed hashing here means solving the key collisions using just the table (linear probing, quadratic probing etc...) and open hashing means solution using chaining.
   When deleting element from the hash table we need to mark that a element was deleted from that index. Otherwise the deletion might break the find path. When searching for some element we continue the search further if we find a index that is marked deleted. We can insert new element into index that is marked deleted.

7. In section c) number 33 does not find any index. Every try finds a taken index: the only empty places are in indices 1 and 4. The hash code of number 33 is 2, and quadratic probing tries indices $2 + j^2 \mod 11$, $j = 1 \ldots$. These indices are $2 + 1^2 = 3 \mod 11$, $2 + 2^2 = 6 \mod 11$, $2 + 3^2 = 0 \mod 11$, $2 + 4^2 = 7 \mod 11$, $2 + 5^2 = 5 \mod 11$, $2 + 6^2 = 5 \mod 11$, $2 + 7^2 = 7 \mod 11$, $2 + 8^2 = 0 \mod 11$, $2 + 9^2 = 6 \mod 11$, and $2 + 10^2 = 3 \mod 11$. We don't need to try $j \geq 11$ because $(11x + y)^2 = 11(11x^2 + 2xy) + y^2 = y^2 \mod 11$.

index	values (a)	values (b)	values (c)
0	{ 3 }	3	3
1			
2	{11, 33 }	11	11
3	{ 15 }	15	15
4		33	
5	{ 100, 45 }	100	100
6	{ 16, 5 }	16	16
7	{ 20, 9 }	20	20
8		9	9
9		45	45
10		5	5