CISC 233 Essential Algorithms Problem Set # 4
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Problem 1. *Draw a recursive tree of the worst case for QuickSort. What is the time complexity?*

Problem 2. *Suppose you have been given an algorithm that can find the median in $O(n)$, if you use this algorithm for QuickSort, what is the time complexity in this case? discuss your answer.*

Problem 3. *Demonstrate the operation of the Quicksort algorithm with the following array:* $[4, 2, 9, 6, 23, 12, 5, 1]$ *At each stage, identify the subarray, the pivot and the partitions. (you can use any partition algorithm you like, make sure to explain what it is)*

Problem 4. *Illustrate the operation of LOMUTO PARTITION on the array (No sorting required)*

$$A = \langle 13, 19, 9, 5, 12, 8, 7, 4, 21, 2, 6, 11 \rangle$$

Problem 5. *Illustrate the operation of HOARE PARTITION on the array (No sorting required)*

$$A = \langle 13, 19, 9, 5, 12, 8, 7, 4, 21, 2, 6, 11 \rangle$$

Problem 6. *Describe a Hash table and state what is used for. List several advantages and disadvantages of using a hash table.*

Problem 7. *Briefly describe the difference between conflict resolution by Chaining and conflict resolution by Open Addressing. List a few advantages and disadvantages of each.*

Problem 8. *What are the average and worst case for (consider all possible scenario):*

- *Inserting items into a hash table?*
- *Deleting items from a hash table?*
- *Looking up key in a hash table?*

Problem 9. *Assume that we have a hash table with size $m = 13$ and we use double hashing to address collisions. The double hashing function is $h(k, i) = (h(k) + i \cdot h'(k)) \mod m$, where $h(k) = k \mod 13$ and $h'(k) = 2 + k \mod 5$. the variable i represents the ith attempt to resolve a collision using double hashing. Answer the following questions.*

1. *Given an empty hash table, show the hash table when inserting 15, 3, 19, 37, 32, 24, 43 in order step by step.*
2. *Given the following hash table, show the records examined when searching for 17.*

0	1	2	3	4	5	6	7	8	9	10	11	12
		15		30	5			21		10	24	12

Problem 10. *Consider a hash table of size $m = 10$ with the simple hash function $h(k) = k \mod 10$. Discuss how the following collision resolution techniques would resolve insertions of the keys 5, 15, 25, 35 into the hash table:*

1. *Linear Probing: If a collision occurs at $h(k)$, the next slot is checked at $(h(k) + 1) \mod m$, then $(h(k) + 2) \mod m$, and so on until an empty slot is found.*
2. *Quadratic Probing: If a collision occurs, the i-th slot checked is at $(h(k) + i^2) \mod m$, where i is the number of probes.*
3. *Chaining: Each slot in the hash table points to a linked list of entries that hash to the same index.*
4. *Double Hashing: A second hash function $h'(k)$ is used. If a collision occurs at $h(k)$, the next slot is at $(h(k) + i \cdot h'(k)) \mod m$, where i is the attempt number.*

Illustrate the final state of the hash table for each technique after all keys have been inserted.