1. [5 points] Please show the final tree status after inserting 2, 1, 4, 5, 9, 3, 6, 8 into an initial empty AVL tree.
2. [4 points in total] An intermediate status of an RB-Tree is shown as below. Based on our class discussion, please rebalance the tree and maintain the RB-Tree properties. Draw your RB-tree on the right.

2.1 [2 points]

2.2 [2 points]

1. [3 points] True or False

3.1 A hash function may give the same hash value for distinct input data. **True**

3.2 When the load factor exceeds a threshold, rehashing is performed. A key stored in the original hash table is copied to the bin of the same index in the new hash table. **False**

3.3 A collision in a hash table happens when two or more input data hash to the same index. **True**

4. (8 points) Show results of the following hash algorithms:  
Given the hash algorithm hash(x) = x mod m  
insert (36, 52, 30, 22, 38, 54)  
m=16, linear probing

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | 36 | 52 | 22 | 38 | 54 |  |  |  |  |  | 30 |  |  |

m=16, quadratic chaining

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | 36 | 52 | 22 | 38 |  |  | 54 |  |  |  | 30 |  |  |

m=16, double hashing, use hash2(key) = 7 – (key mod 7)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | 36 |  | 22 | 38 | 52 |  | 54 |  |  |  | 30 |  |  |

m=16, separate linear chaining

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| null | null | null | 36 🡪52🡪null | null | 22🡪38🡪54🡪null | null | null | null | null | null | null | null | 30 | null | null |