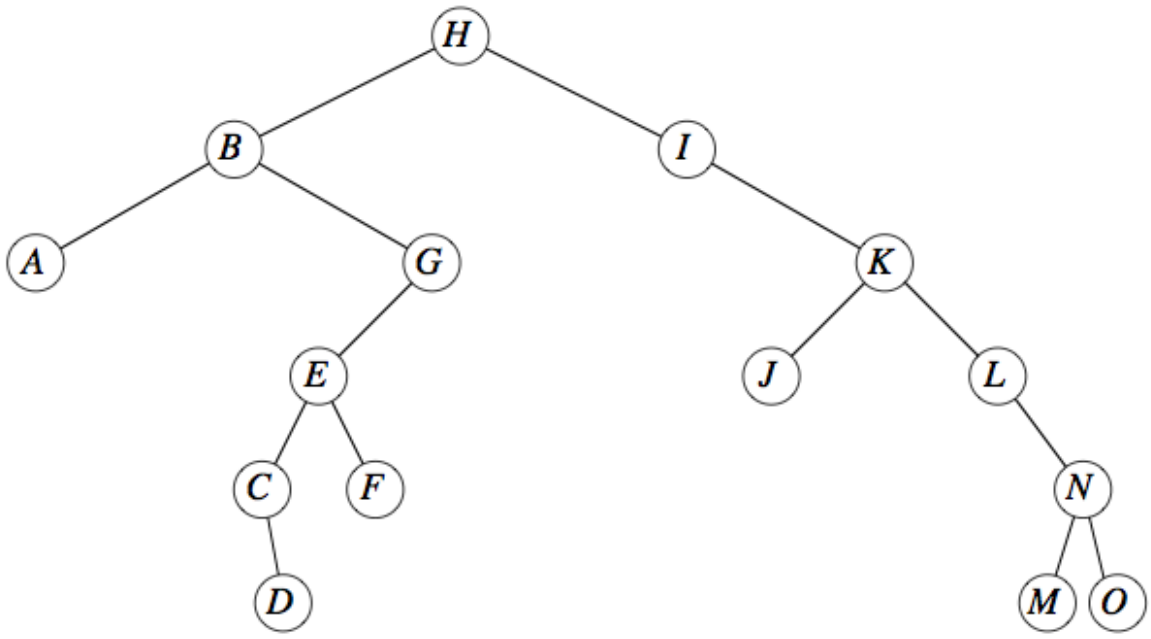
CS 303 Algorithms and Data Structures
Exam-2

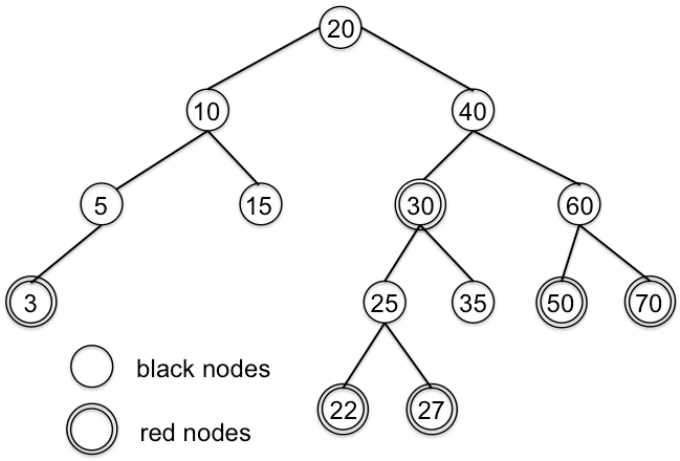
50 points. 75 minutes. Open Book/Notes. Name:_____

1. Show what the tree would look like after the following changes are made to the following binary search tree (make sure to include all the intermediate steps): **[12 points]**

a) Delete node with value I
b) Delete node with value G
c) Delete node with value K
d) Delete node with value B



2. Is the following tree a red-black tree? Explain your answer. If not, make appropriate changes to make this a valid red-black tree. [**4 points**]



Show what the tree would look like after you insert the following values to the valid red-black tree obtained from above (make sure to explain all the steps involved and mark the red and black nodes accordingly): **[10 points]**

a. 7
b. 48
c. 21

3. Consider inserting the keys *10, 22, 31, 4, 15, 28, 17, 88, 59* into a hash table that has 9 slots. Demonstrate what happens when the keys are inserted into a hash table:

a) With collisions resolved by chaining and the hash function $h(k) = k \bmod 9$. **[6 points]**

b) Using open addressing with the auxiliary hash function $h'(k) = k$ *and* double hashing with $h_1(k) = k$ and $h_2(k) = 1 + (k \bmod (m - 1))$.**[6 points]**

4. Suppose you are writing software for a department store to manage the store's charge card system. Customer information, organized by the card's number, must be maintained and accessed by store employees whenever the customer makes a purchase using their card. Once a month, a report on card usage must be generated that lists the customers in order by card number. Discuss the trade-offs between using a binary search tree and a hash table to solve this problem. [**6 points**]

5. For each of the two types of lists in the following table, compute the asymptotic worst-case running time for each dynamic-set operation listed and complete the table below. **[6 points]**

Operation	Unsorted, singly linked list	Unsorted, doubly linked list
SEARCH(L, k)		
INSERT(L, x)		
DELETE(L, x)		