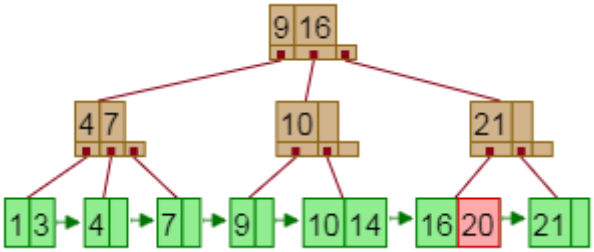
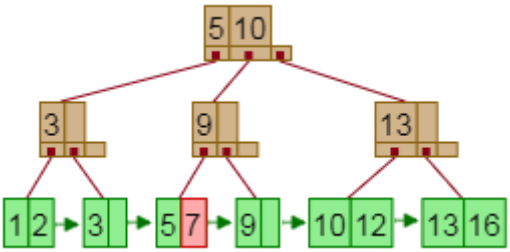
CS 353 Spring 2020
Homework 5 Solutions
Due: 22 April, Wednesday till midnight

Q.1 [18 pts, 6 pts each]
Consider a B+ tree with n = 3. Construct the tree for each of the following parts, **using the "insertion algorithm provided in the textbook"**.
(a) Draw the tree after inserting the following keys in the given order.
10, 9, 3, 7, 4, 21, 16, 1, 14, 20.
(b) Draw the tree after inserting the following keys in the given order.
13, 10, 1, 2, 5, 3, 9, 16, 12, 7.
(c) Draw the tree after inserting the following keys in the given order.
3, 10, 12, 4, 13, 15, 14, 16, 18, 17, 19, 20.

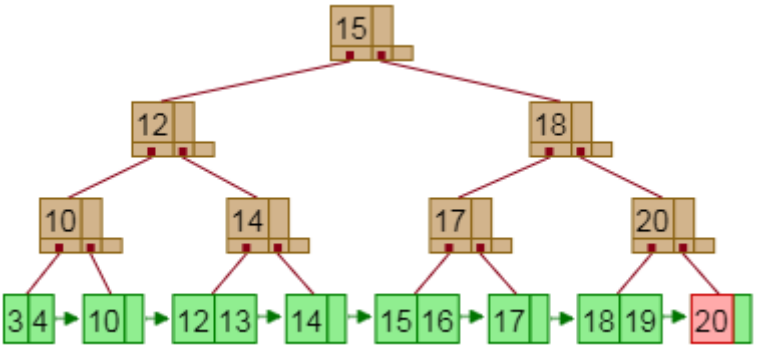
Answer:
(a)



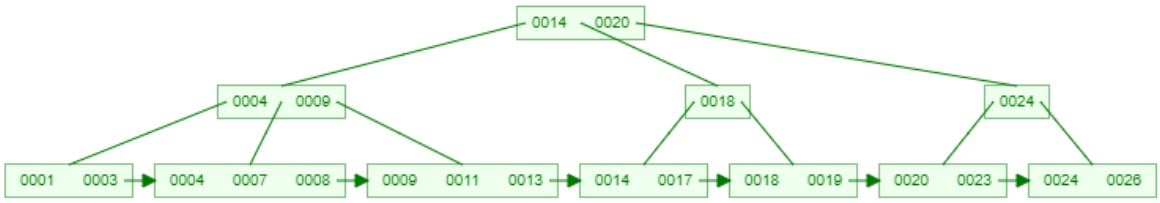
(b)



(c)

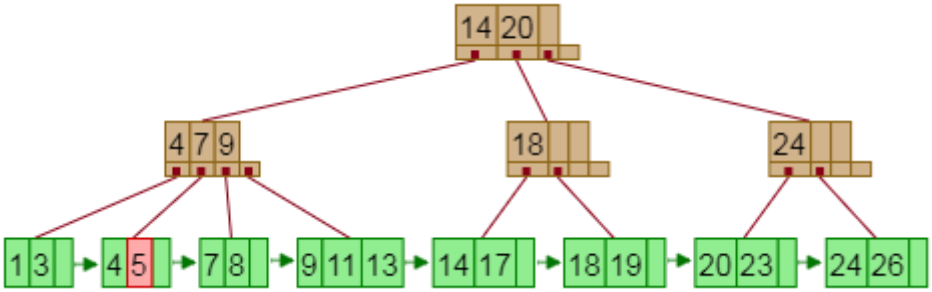


Q.2 [32 pts, 8 pts each]
Consider the following B+ tree with n = 4. For the following operations, **use the insertion / deletion algorithms provided in the textbook**.

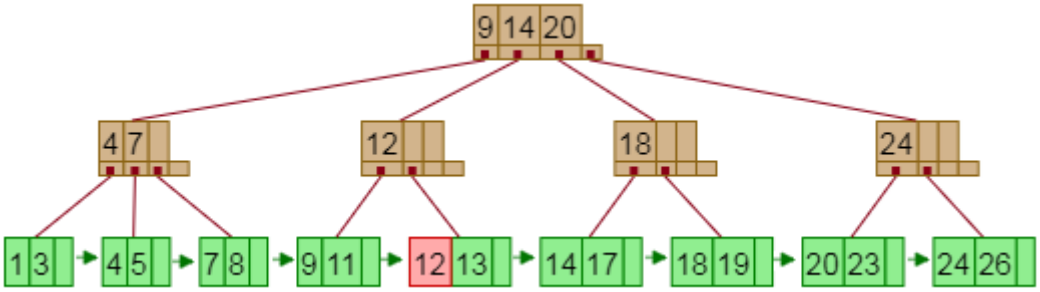


(a) Draw the tree after insertion of an entry with search key value k = 5.
(b) Draw the tree after insertion of an entry with search key value k = 12 to the resulting tree in (a).
(c) Draw the tree after deletion of the entry with search key value k = 18 from the resulting tree in (b).
(d) Draw the tree after deletion of the entry with search key value k = 19 from the resulting tree in (c)

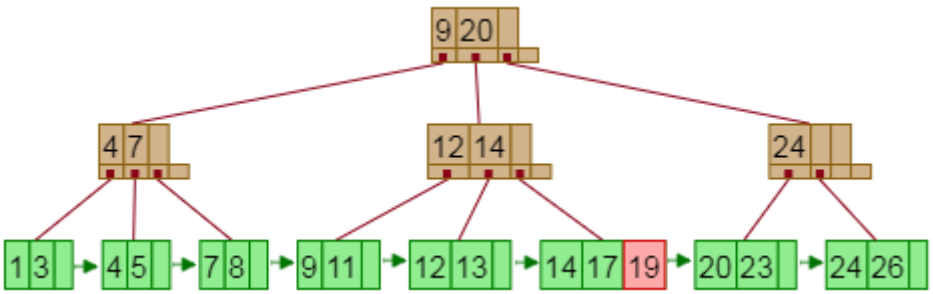
Answer:
(a)



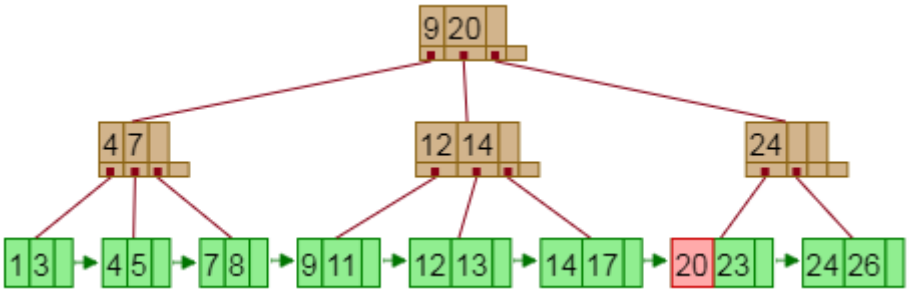
(b)



(c)



(d)

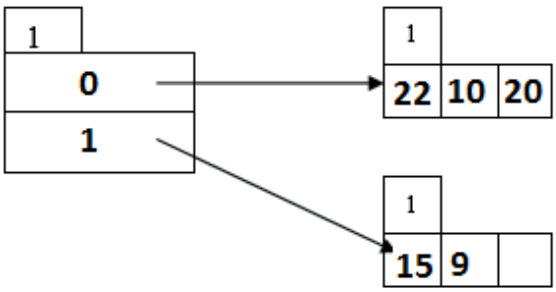


Q.3 [50 pts, 25 pts each]
Consider an extendable hash structure where buckets can hold 3 search-key values. Suppose that the global-depth is Y. Then the hash function returns Y Least Significant Bits (i.e., use the least significant bits of the hash value, **not** the most significant bits as shown in the textbook). Assume that global-depth and local-depths of the extendable hash table are initially 1. Show the contents of the hash table and the bucket address table after all the search-key values are inserted / deleted. Indicate which insertions lead to bucket splits.
(a) Insert 15, 22, 10, 20, 9, 4, 12, 8, 16, 18 and 14.
(b) Delete 18, 14, 22, 20, 12, 4 and 10 from the resulting structure in (a).

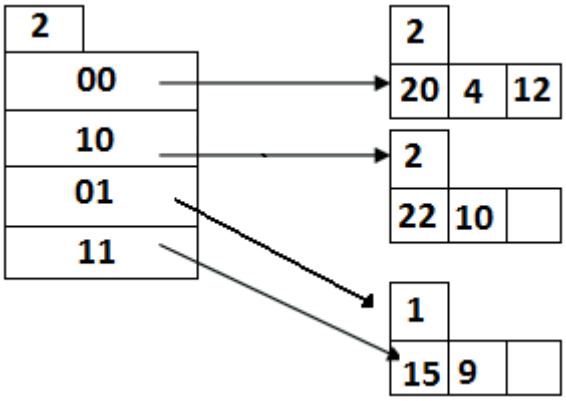
Answer:
Input representation in bits:

Input	16	8	4	2	1
15	0	1	1	1	1
22	1	0	1	1	0
10	0	1	0	1	0
20	1	0	1	0	0
9	0	1	0	0	1
4	0	0	1	0	0
12	0	1	1	0	0
8	0	1	0	0	0
16	1	0	0	0	0
18	1	0	0	1	0
14	0	1	1	1	0

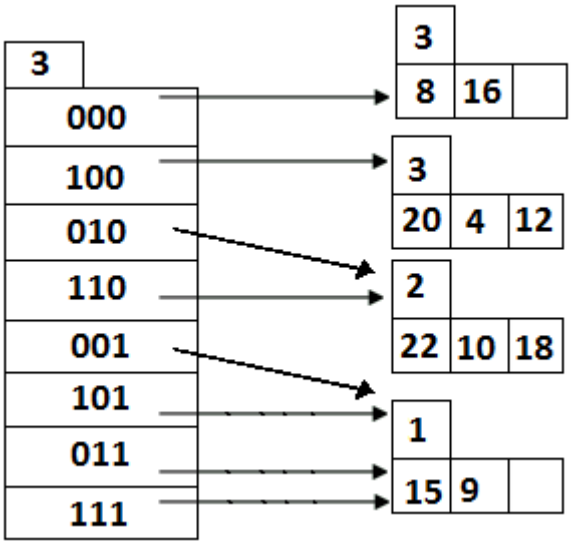
(a)



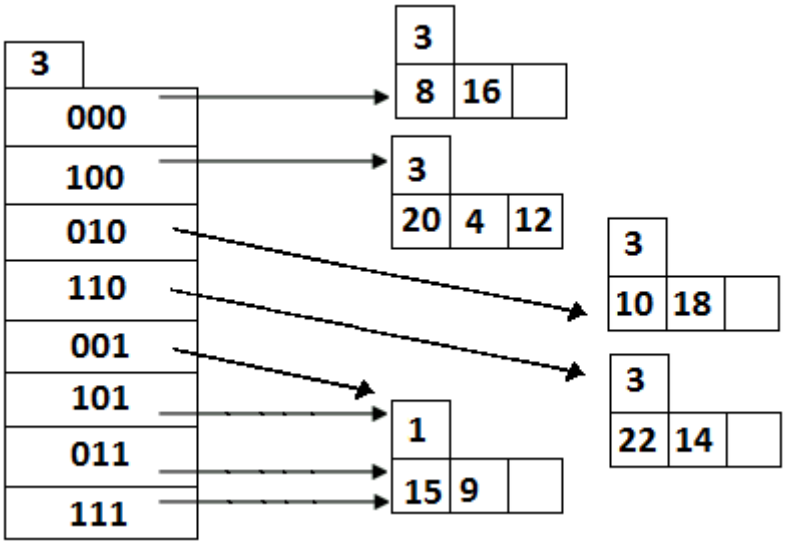
Insertion of 4 leads to split, then add 12



Insertion of 8 leads to split, then add 16 and 18

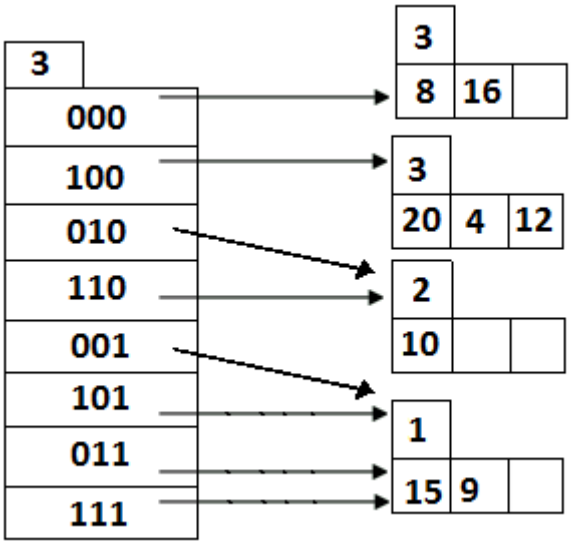


Insertion of 14 leads to split

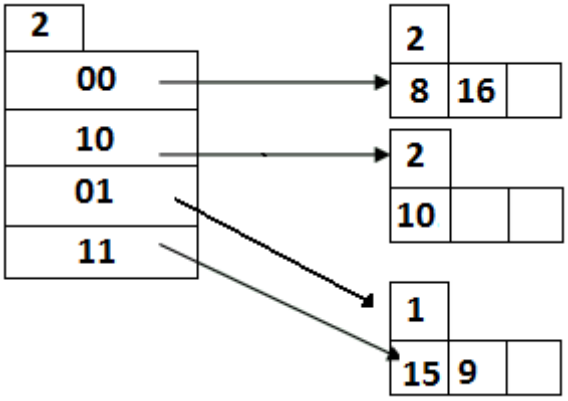


(b)

Deletion of 22 leads to merge



Deletion of 4 leads to merge



Deletion of 10 leads to merge