

**Department of Computer Science,
Data Structures (CSC212)
1st Semester 2009-10
Final Exam
13/2/1431 (28/1/2010G)**

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Time: 3 hours **Marks: 100**

Question 1 (2 x 10 = 20 marks)

- (a) What is the step count of the following code segment:

```
i = 0;  
while (i <= 10)  
    i = i + 2;
```

- ✓ (b) Order the following functions by their growth rates: 2^n , $4n$, n^3 , $n \log n$, 2^{10} , $100 \log n$.
- (c) What is the time complexity of insert and remove operation in a doubly-linked list?
- (d) What type of structure do trees have?
- (e) If a binary tree has n nodes, how many edges will it have?
- (f) Give a formula for the number of nodes in a *full* binary tree in terms of its height, h .
- (g) What is the *worst-case* time complexity of the FindKey operation in an AVL Tree?
- (h) Draw an expression tree for the expression: $(a + b) - (c / (d + e))$.
- (i) Which traversal order processes the leaves of a binary tree before processing non-leaf nodes?
- (j) What is the minimum and maximum number of children a root can have in a B+-tree of order 1000?

Question 2 (4 + 1 + 12 + 3 marks)

We are interested in counting the number of times a word occurs in a text file.

- (a) Suggest the most suitable ADT to manipulate the set of words for this problem.
- (b) Give a graphical representation of the ADT.
- (c) Give a full specification of the ADT.
- (d) Give the time complexity for each operation given in the specification.

Note that the main method reads the text file and passes the words one by one to the ADT.

Example:

Given the following text file :

“Yesterday, under the direction of Rector Abdullah Al-Othman, King Saud University began holding its fifth conference for exploring the current issues of **biotechnology** research and applications. This workshop is held in collaboration with the Center of Excellence in **Biotechnology**”

Query: Give the word count of “biotechnology”. **Output:** 2

Question 3 (10 + 10 marks)

- (a) Assume that a heap of integers is represented simply using an array of integers. Write a Java method that takes as input an array of integers and the number of elements in the array, and tells whether the array is a max-heap or not.

```
public boolean IsMaxHeap (int [] heap, int n)
```

- (b) In a binary tree, a node has either no children, one child, or two children. Write a recursive Java method, within the binary tree class, that returns the number of nodes that have a single child.

```
public int NumberOfSingleChildNodes (BTNode<T> root)
```

Question 4 (10 + 10 marks)

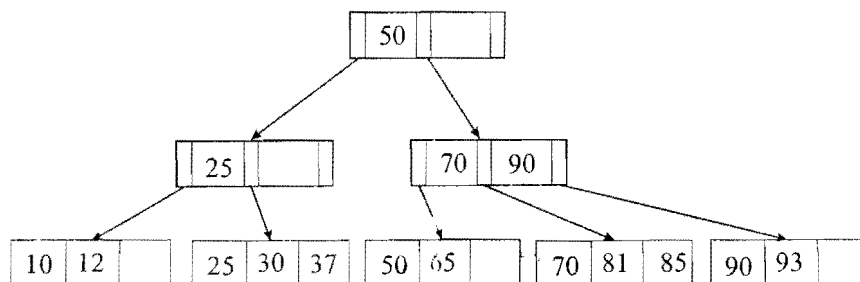
- (a) Assuming that we have a hash table of size 7, we use external chaining to resolve collisions, and we use the following hash function: $H(Key) = Key \bmod 7$. If the hash table is initially empty, show the hash table resulting from the following insert operations: **Insert** (16), **Insert** (14), **Insert** (9), **Insert** (4), **Insert** (37), **Insert** (35), **Insert** (3), **Insert** (11). Note that these operations are applied in the order they appear (i.e., 16 is inserted first and 11 is inserted last).
- (b) Suggest a hash table size and a hashing function so that we can insert the above keys in (a) without any collision. Try to make the table size as small as possible.

Question 5 (6 + 4 + 3 + 3 + 4 marks)

- (a) Consider the following B⁺-tree of order 3.

- (i) Insert 30, 35, 60, 65, and 75 into the above tree and draw the resulting B⁺-tree.
- (ii) Insert 50 in the B⁺-tree obtained in part (i) and draw the resulting tree.

- (b) Consider the following B⁺-tree of order 3.



- (i) Delete 85 and 12, and draw the resulting B⁺-tree.
- (ii) Delete 81 from the B⁺-tree obtained in part b (i) and draw the resulting B⁺-tree.
- (iii) Delete 25 from the B⁺-tree obtained in part b (ii) and draw the resulting B⁺-tree.

Fall 2009

Q1-a) $i = 0;$

while ($i \leq 10$)

$i = i + 2;$

step count = $1 + 7$

= 8

i	$i \leq 10$
0	✓
2	✓
4	✓
6	✓
8	✓
10	✓
12	X

b) $2^n, 4n, n^3, n \log n, 2^{10}, 100 \log n$
after ordering them:

$4n, 100 \log n, n \log n, n^3, 2^{10}, 2^n$

c) $T(n)$ of Insert and remove in Double linked list = $O(1)$.

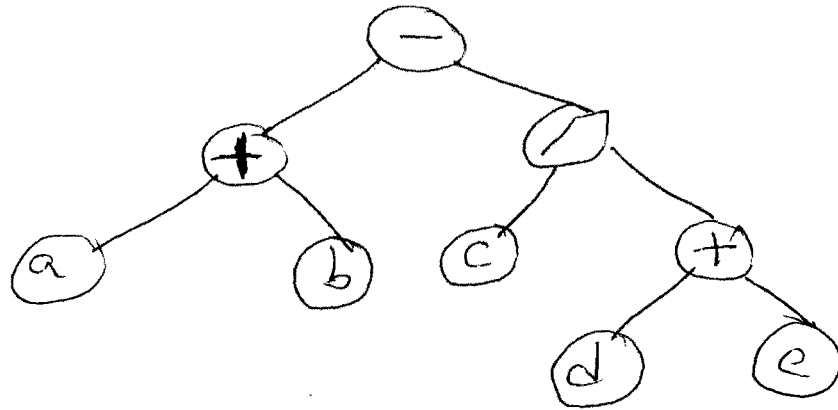
d) Trees have a nested or a hierarchical structure.

e) If a binary tree has n nodes, then it will have $n-1$ edges.

f) number of nodes in a full tree,
 $2^h - 1$

g) Find key operation (best and worst) has $O(\log n)$.

h) $(a + b) - (c / (d + e))$



i) post order.

j)

$M = 1000$.

root can have minimum = 2 child
and maximum $m(1000)$ child.

Q3

a

```
public boolean IsMaxHeap(int [] heap, int n)
{
    for (int i = 1; i <= n/2; i++)
    {
        if (heap[i] < heap[2*i] || heap[i] < heap[2*i+1])
            return false;
    }
    return true;
}
```

Q3 public int NumberOfSingleChildNodes (BTreeNode<T> root)

b) { if (root == null)

return 0;

else if ((root.left == null && root.right != null) || (root.left != null && root.right == null))

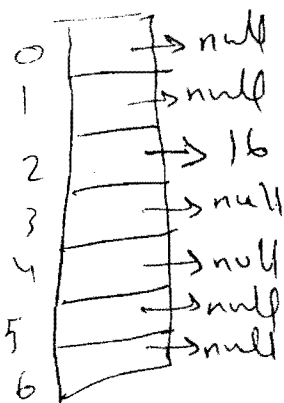
return 1 + NumberOfSingleChildNodes(root.left) + NumberOfSingleChildNodes(root.right);

else return NumberOfSingleChildNodes(root.left) + NumberOfSingleChildNodes(root.right);

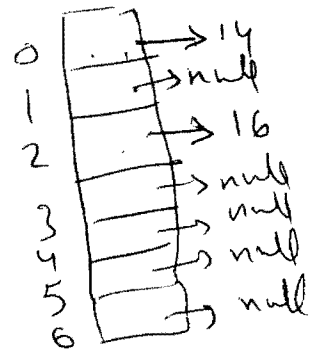
}

Q4) table size 7 | $H(\text{key}) = \text{key} \bmod 7$

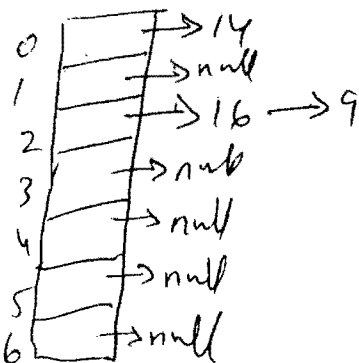
insert(16) = $16 \bmod 7 = 2$



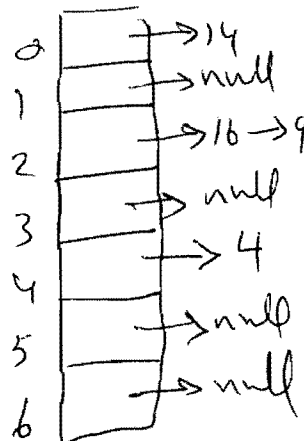
insert(14) = $14 \bmod 7 = 0$



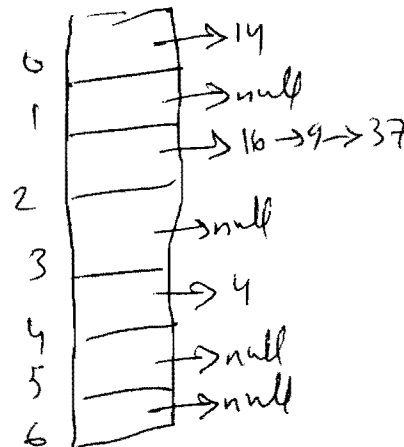
insert(9) = $9 \bmod 7 = 2$



insert(4) = $4 \bmod 7 = 4$

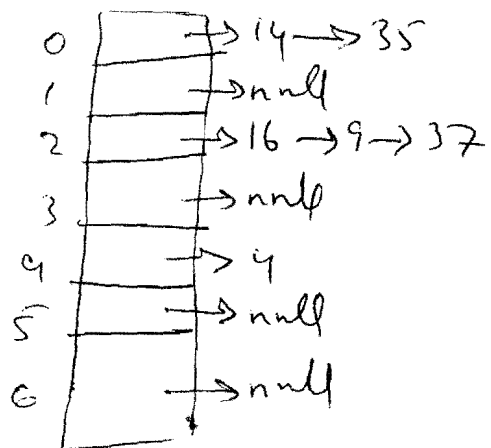


insert(37) = $37 \bmod 7 = 2$



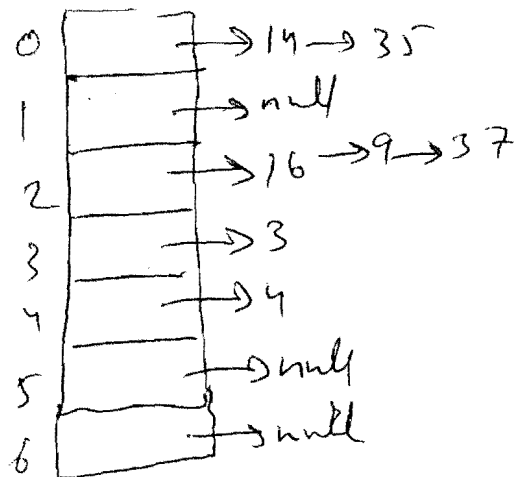
Insert (35)

$$35 \bmod 7 = 0$$



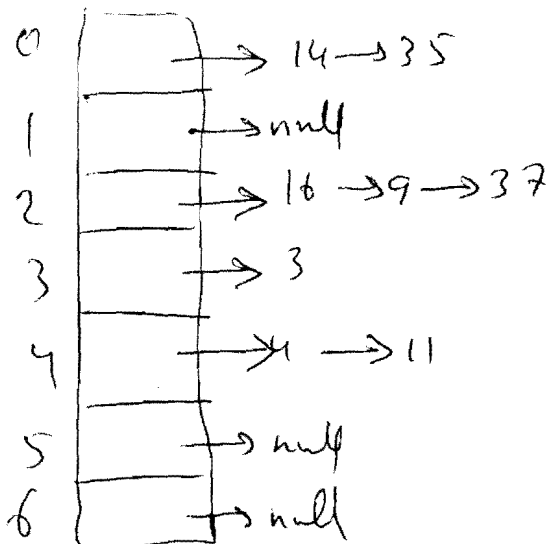
Insert (3)

$$3 \bmod 7 = 3$$



Insert (11)

$$11 \bmod 7 = 4$$



Q4
b

$$H(\text{key}) = \text{key} \bmod 9$$

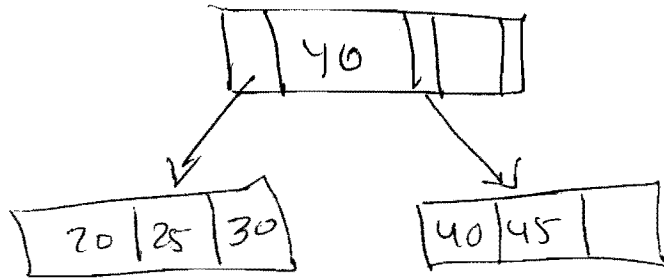
table size = 9

Q 5
a/i

Order (M) = 3

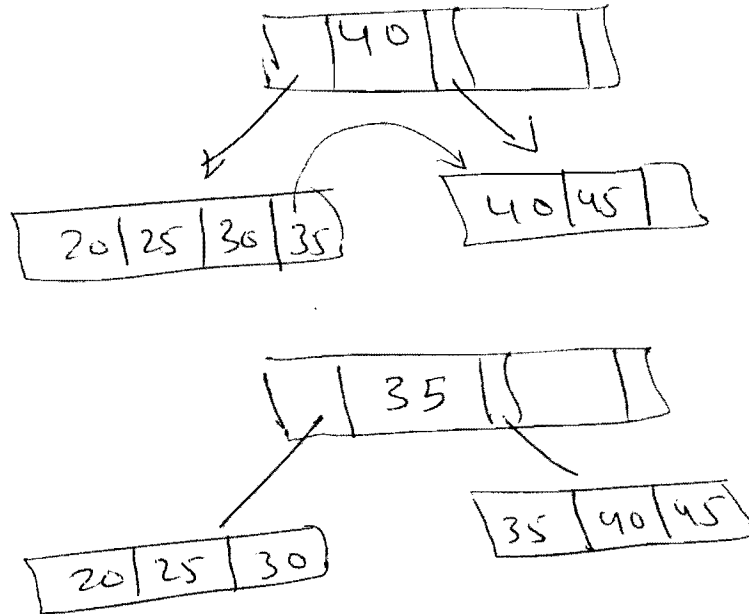
Insert 30

Normal
Case.

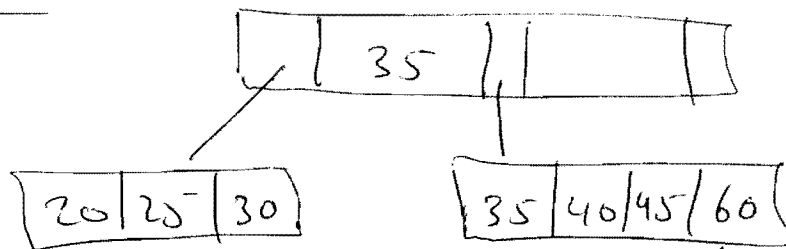


Insert 35

transfer 35
and adjust
two none-leaf
node.

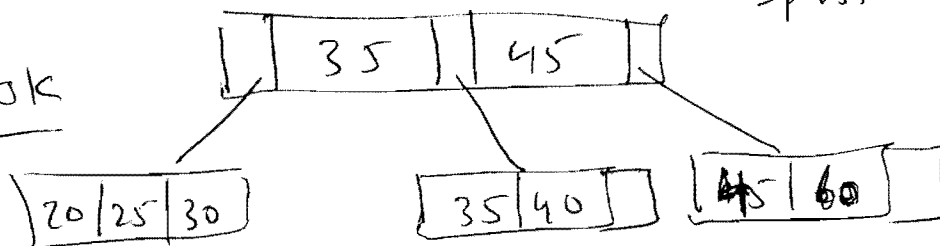


Insert 60



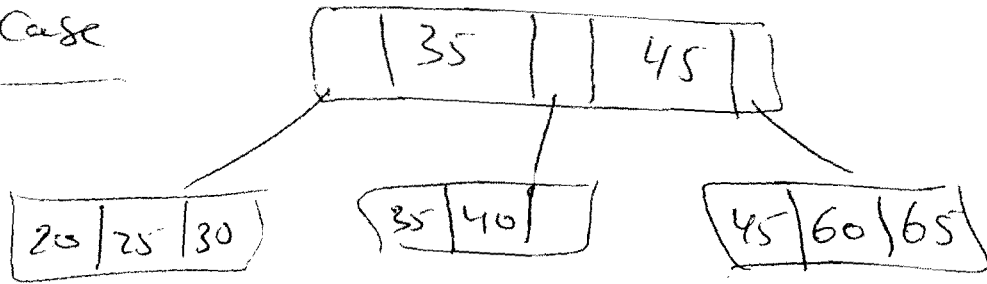
over flow
cannot transfer
split the node.

none-leaf
node is OK

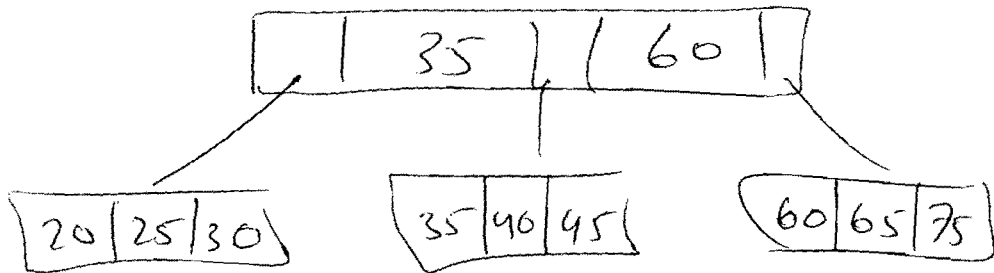
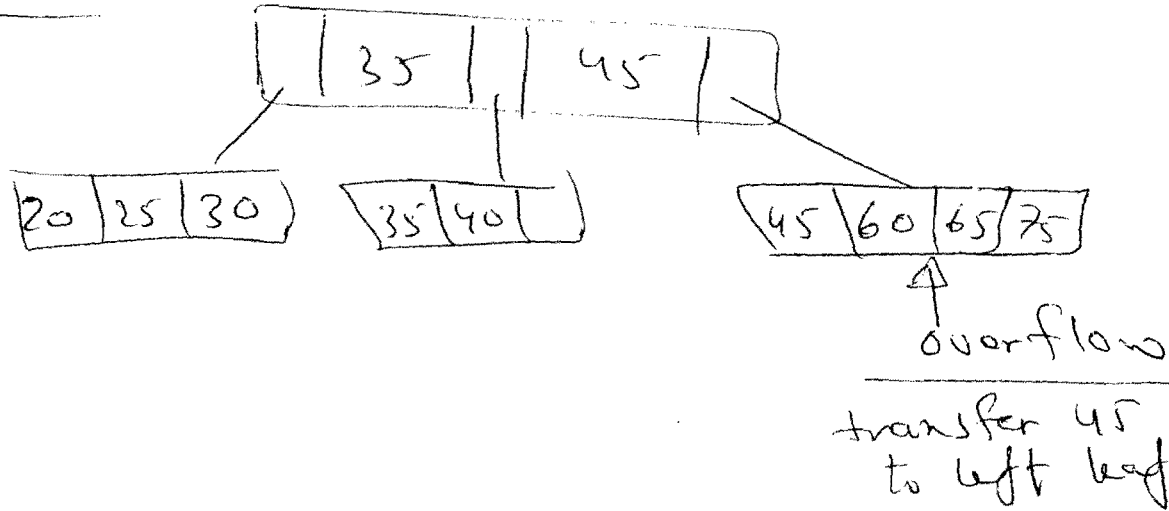


Insert 65

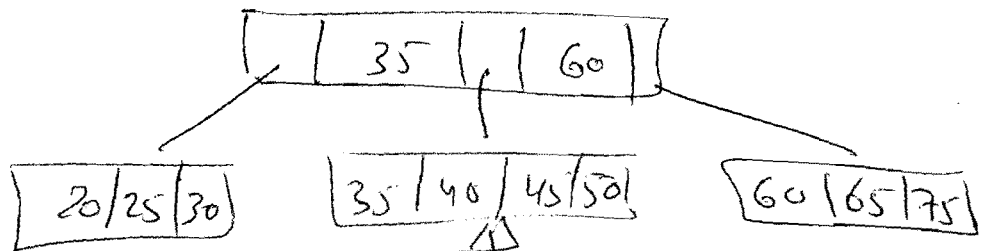
Normal Case



Insert 75

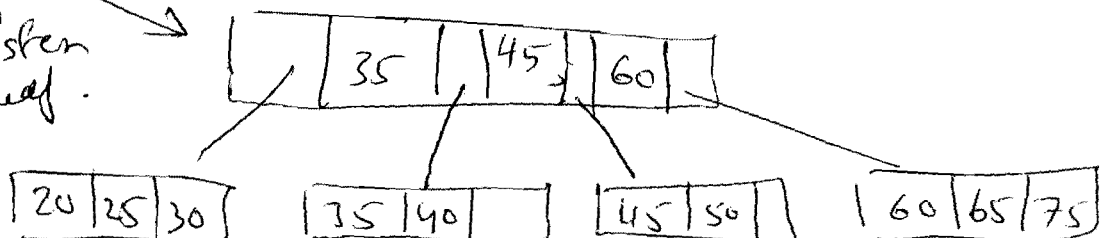


Q5/a/ii
Insert 50



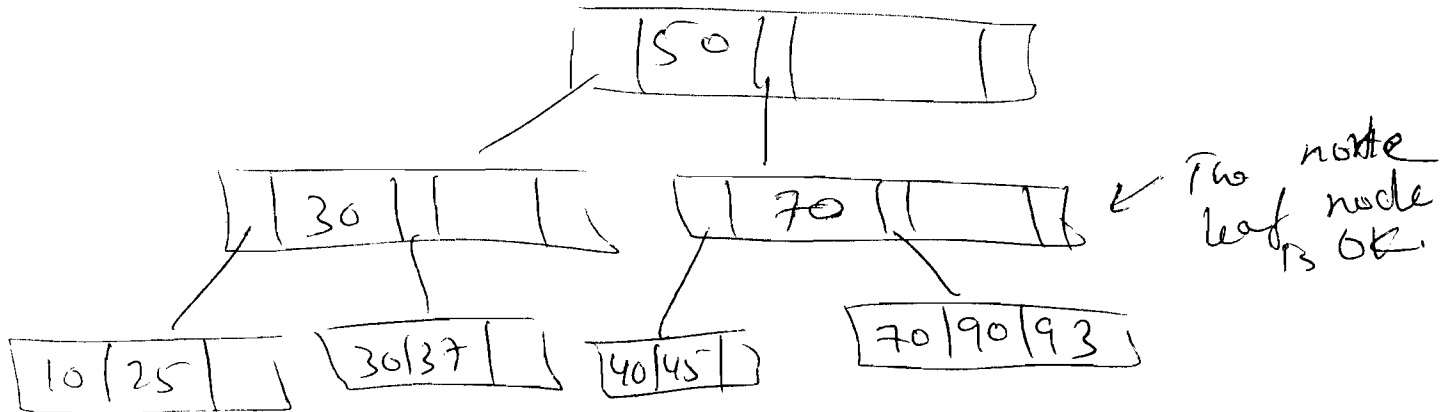
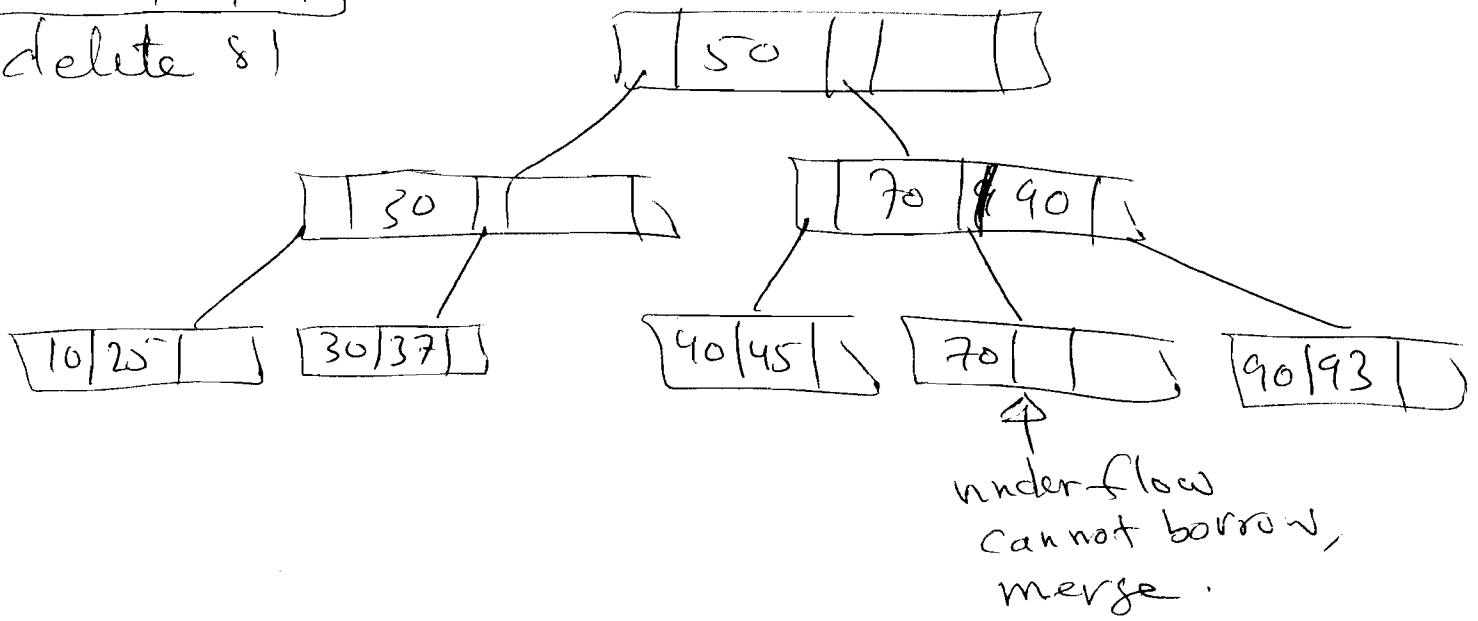
Over Flow
Can not transfare
Split leaf node.

Over flow
in none-leaf
cannot transfer
Split none-leaf.

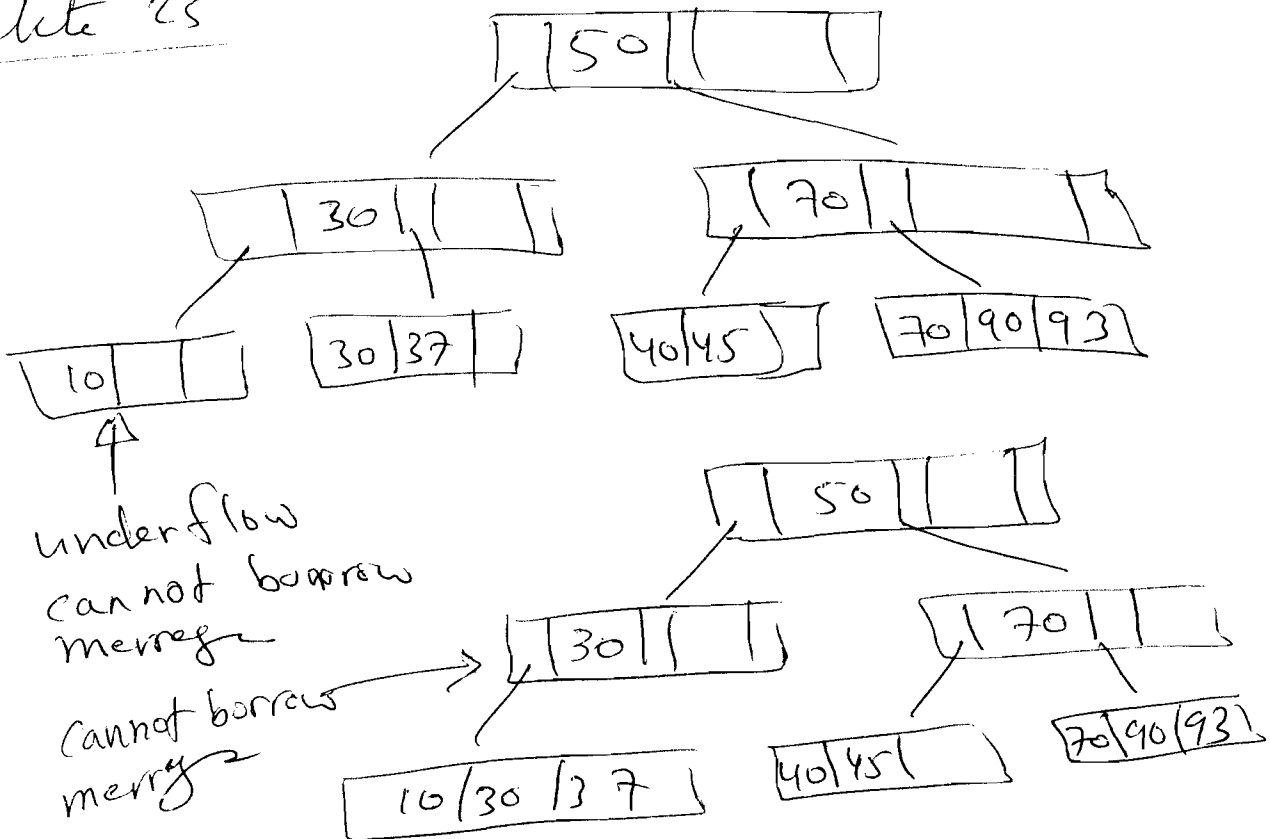


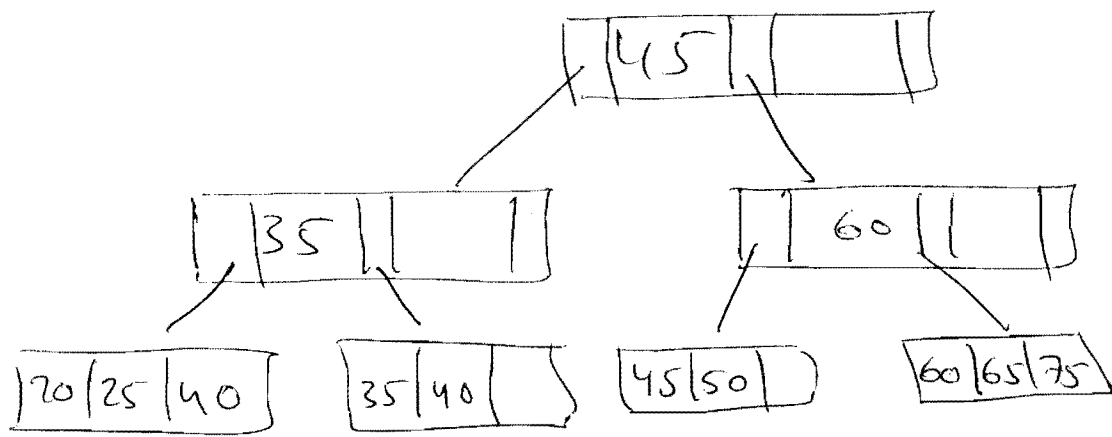
Q5/6/11

delete 81



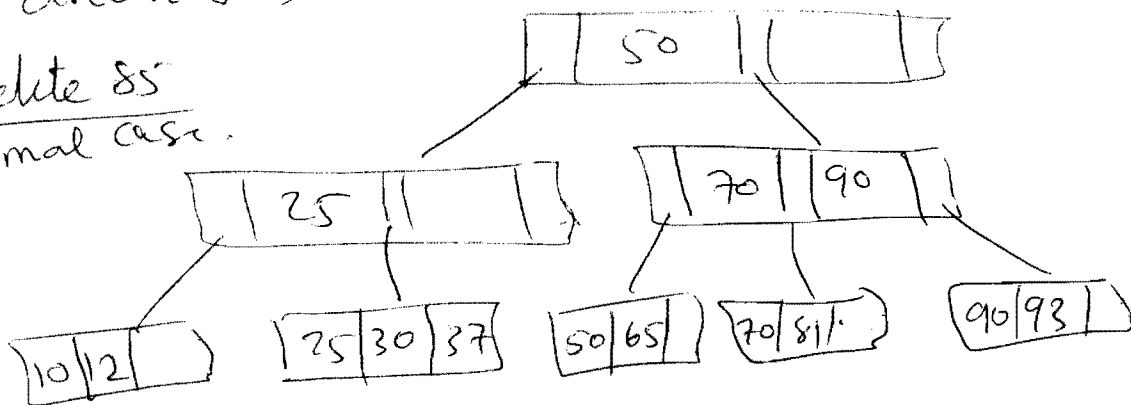
delete 25



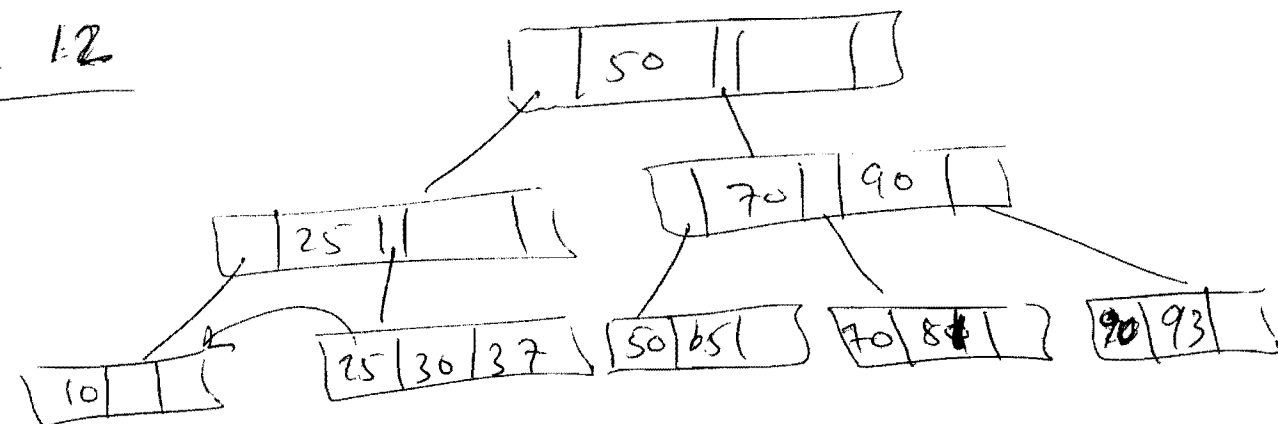


Q5 arden (M) 3.

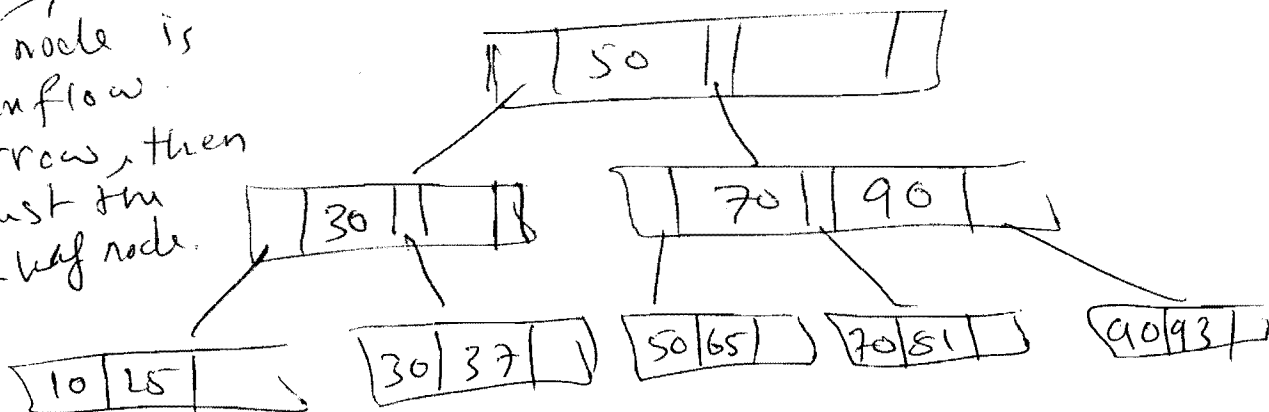
b delete 85
Normal case.



delete 12



leaf node is underflow.
borrow, then adjust the non-leaf node.



cannot
borrow 1

this is
new root

